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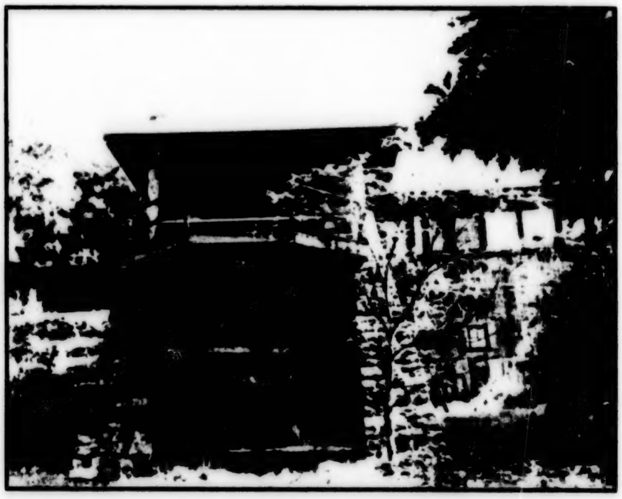
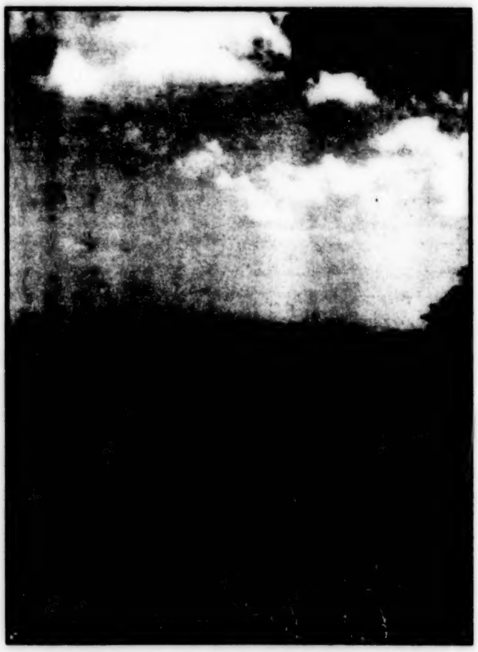
Resource Assessment of the June 27 and 28, 1995 Floods and Debris Flows in Shenandoah National Park

Editors: John Karish, Tom Blount, Bob Krumenaker

Natural Resources Report NPS/SHEN/NRR-97/001





United States Department of the Interior
National Park Service

Shenandoah National Par
Center for Resources

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April 1997

National Park Service
Shenandoah National Park
Center for Resources
3655 US Highway 211E
Luray, Virginia 22835

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Introduction

What Happened?

Stationary thunderstorms and prolonged, intense rains in late June 1995 caused major ecological changes to watersheds and damaged roads and trails throughout Shenandoah National Park (Figure 1). Rains, beginning in some areas as early as June 22, saturated the soil over a five-day period. Then, when heavy rains fell on June 27 and 28, significant mass wasting activity, including debris flows, mudflows, slumps, blowouts, and landslides, occurred and stream drainages flooded. A majority of the mass wasting that occurred in and near the Shenandoah National Park (SNP) was debris flows. Early estimates characterize the flood as high magnitude and low frequency, and the debris flows perhaps as being rarer still. There is abundant evidence of similar occurrences throughout the Blue Ridge, including an event in Nelson County, Virginia (just south of SNP) in 1969.

The effects of the storm caught media attention due to the immediate emergency situation that developed. Areas outside the Park that were hardest hit were in Madison, Greene, and Warren counties. More than 800 people were displaced from their homes, 8 deaths were flood related, an estimated 2,000 homes were damaged, and flood waters rendered water treatment plants in several communities inoperable. At one point 12 primary and 400 secondary roads were closed. Park staff immediately mobilized to assist adjacent communities and deal with emergency situations inside and outside the Park, and fortunately there were no deaths within the Park.

A note on terminology: Definitions of geological terms used in this report appear in Appendix A. The term "event" is used throughout the report to indicate the entire rain/debris flow/flood sequence from June 22-28, although in many areas, there was a culminating and dramatic occurrence that likely took place over a matter of minutes.

The Assessment and This Report

As the emergency diminished, Park staff turned to the issue of determining the extent of storm-caused impacts to Park facilities and resources. Teams were mobilized to determine the extent of damage to roads and trails, and develop cost estimates for repairs, if feasible. An incident command team was established to supplement Park staff efforts to assess the impacts on the natural resources of the Park[1], and this report is the combined result of those endeavors. SNP staff prioritized areas to investigate based on initial reconnaissance observations, apparent severity of resource impact, and availability of pre-event monitoring information. Hence, some areas of the Park, including some with extensive pre-event data sets (e.g. Pocosin and Conway drainages), are not included in this report.

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[1] Since most of SNP lacks a baseline cultural resources inventory, it was impossible to assess the impacts on cultural resources. Assessment teams were advised to note any cultural resources found during the course of other assessments, and archaeological surveys of newly exposed landslide scars are expected to be conducted in the course of additional geological investigations.

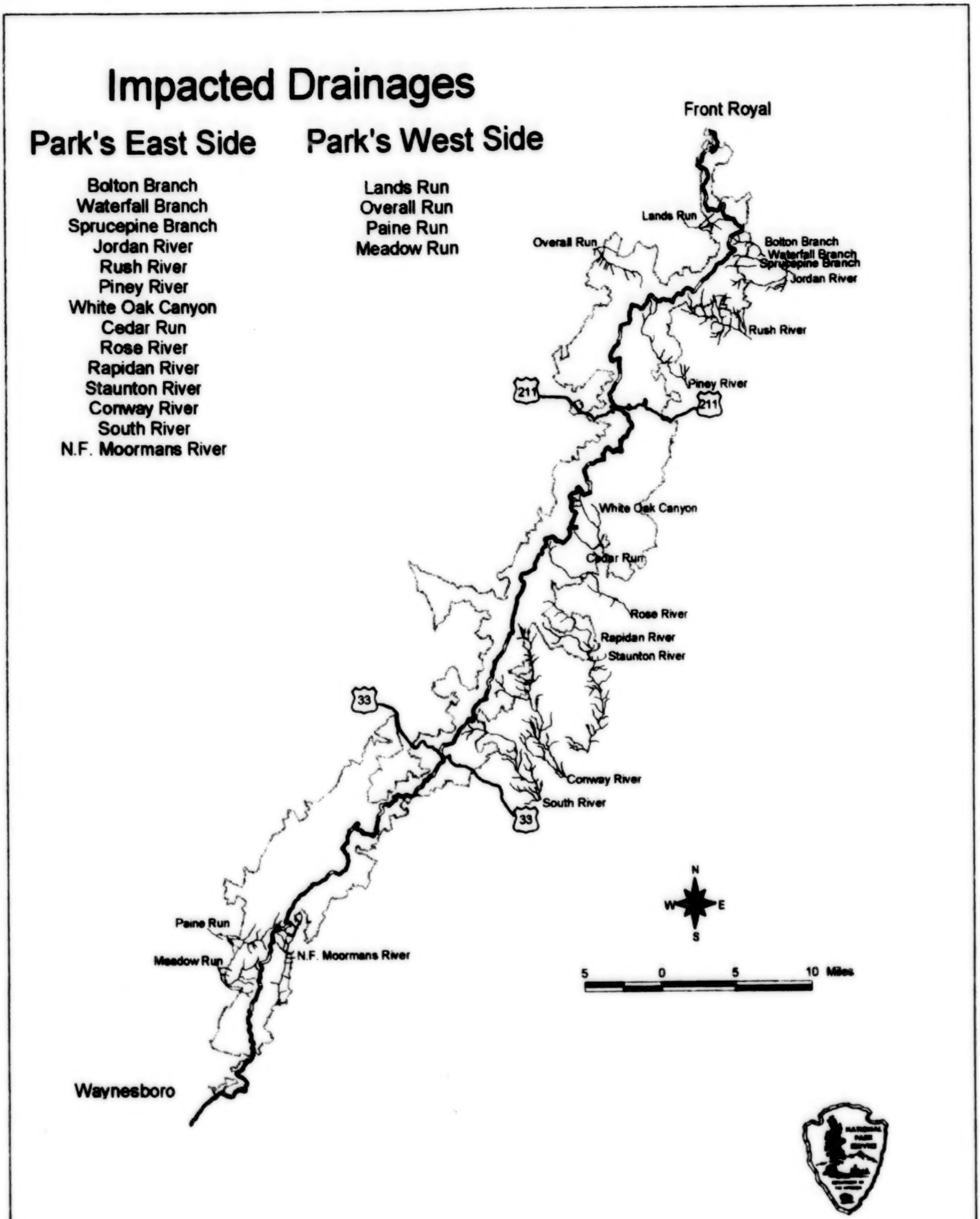

Figure 1. Shenandoah National Park map with streams that were impacted by the 1995 flood identified.

SNP Inventory and Monitoring (I&M) program staff and University of Virginia (UVA) cooperators surveyed many of the affected areas that were coincident with long-term ecological monitoring sites during the first two weeks after the event. This was followed by a rapid on-site appraisal of the Staunton, Rapidan, and North Fork Moormans river drainages (Figures 2 and 3), as well as a slide on Mt. Marshall, the week of July 31, 1995 by an interdisciplinary scientific assessment team. The team consisted of SNP staff as well as scientists and resource managers from other National Park Service units, several universities, and several federal and state agencies. This report is therefore based on observations made on or before August 2, 1995. Contributors are listed in Appendix B.

Events and processes described in this report provide SNP with a number of opportunities. With one of the National Park Service's prototype Inventory and Monitoring programs already in place, SNP is in a unique position to contrast detailed post-event ecosystem monitoring with known pre-event conditions. Fortuitously, some of the most significant changes were concentrated in an area of the Park (Staunton River watershed) with one of the longest and most intensive monitoring data sets for many different ecological components.

Debris flow events can be, and frequently are, devastating to those who live in their path. We have a unique opportunity -- obligation, perhaps -- to obtain an understanding of their development and occurrences and provide the information to our neighbors and others who may be vulnerable; it may help prevent the kind of human tragedies that were associated with this event. The Park boundary is irregular, cutting across watersheds, hence the stewards of upstream and downstream lands will always be linked. We must also recognize that despite the devastation, these events are part of a natural cycle of erosional processes that define these mountains and valleys. We hope to develop an understanding of the processes, in part, to be able to share with Park visitors and the public the sense of excitement and awe of the power of nature.

General Surficial Geology

In Virginia, the Blue Ridge forms a major topographic high separating the piedmont and coastal plain physiographic provinces from the ridge and valley and plateau provinces of the Appalachian Mountains. Shenandoah National Park is entirely within the Blue Ridge province. The rocks underlying the Park belong to three major groups. Granitic rocks formed at great depth about 1.2 billion years ago have been exposed through uplift and erosion along the eastern side of the Blue Ridge; basaltic lava flows, which formed about 600 million years ago, are now exposed in the central and northern sections of the Park; and clastic, silica-rich sedimentary rocks, which are about 550-600 million years old, are now exposed along the western side of the Blue Ridge. All of the rocks were deformed, folded, and chemically altered about 250-350 million years ago by continental collision and thrusting.

The present topography is a result of the physical and chemical properties of these rocks which have undergone slow regional arching or warping and differential erosion. As such, the present landscape is very complex and very old, evolving for perhaps 30 million years. Although bedrock exposures are abundant along the ridge crest and on Old Rag Mountain, most of Shenandoah National Park is covered in a thick mantle or regolith that includes: soil, weathered rock (saprolite), transported debris (colluvium), soils and rock reworked by streams (alluvium),

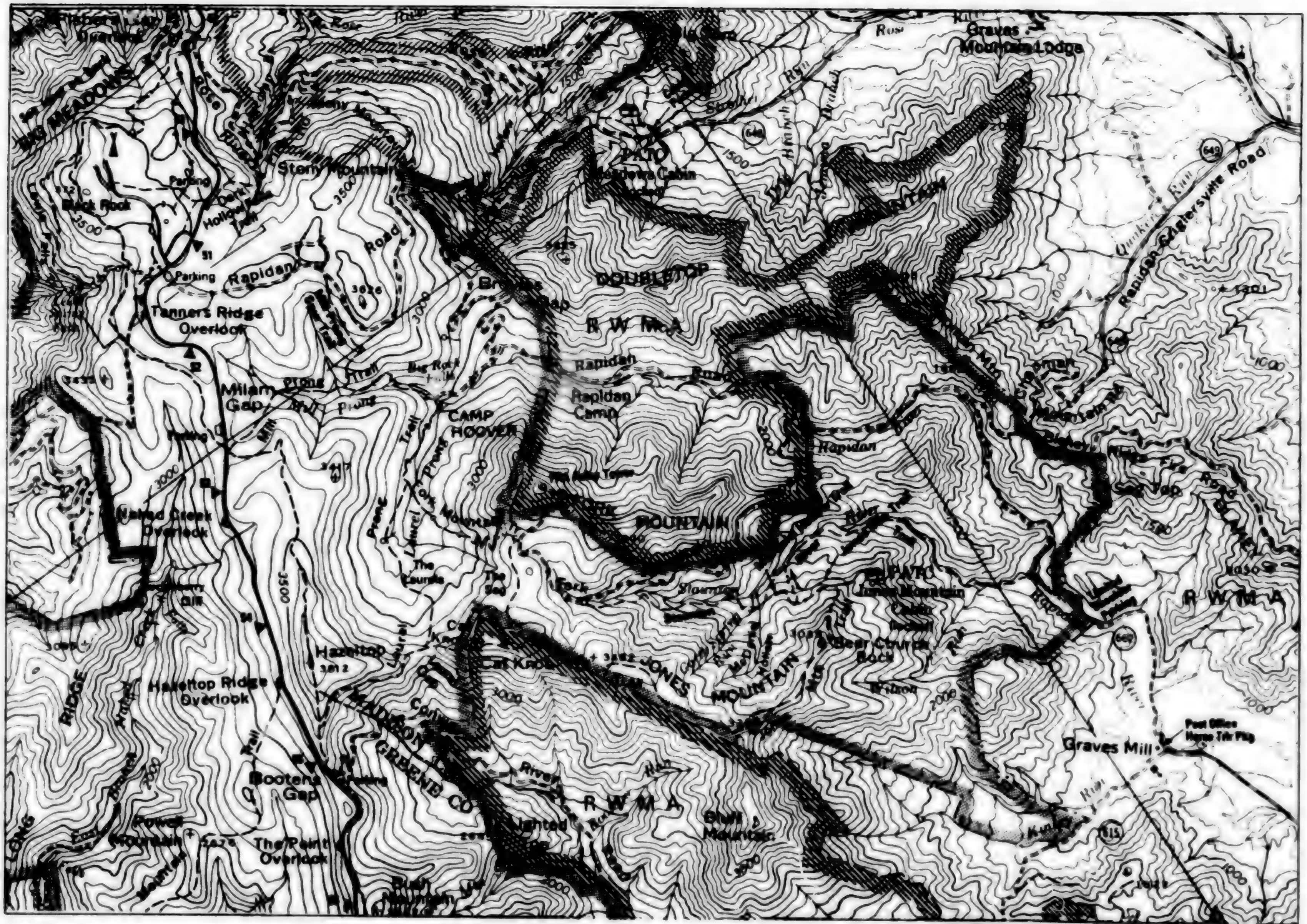

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Figure 2. Staunton and Rapidan River drainages which are located on the eastern slope of the Blue Ridge.

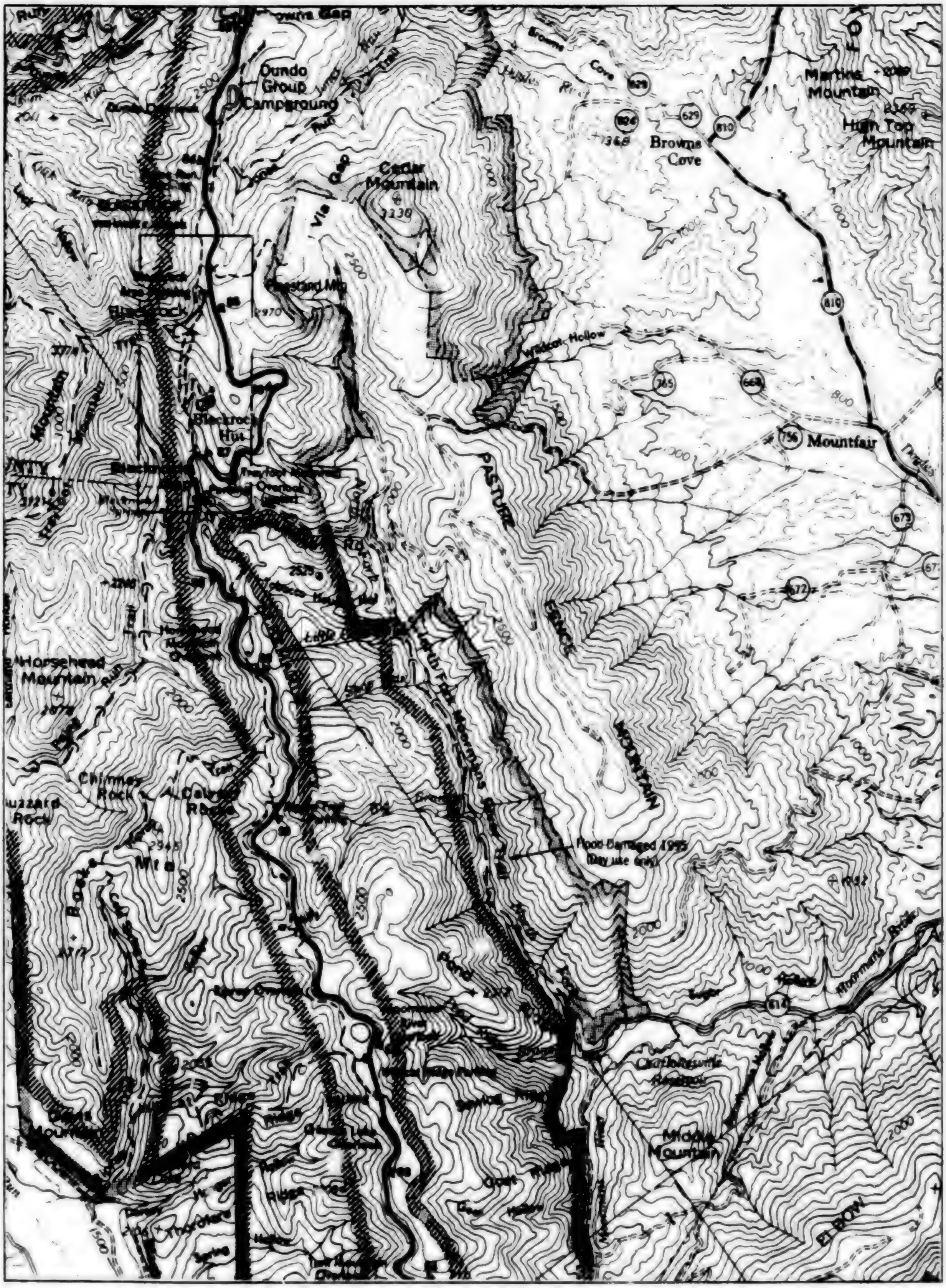

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Figure 3. North Fork Moormans River drainage which is located on the east slope of the Blue Ridge.

large areas of broken rock formed by freezing and thawing of water (blockfields), and remains of ancient landslides and debris flows (stone streams).

The effects of erosion on this landscape have been the rapid removal of mechanically weak and chemically susceptible rocks. Quartz-rich rocks and thick lava flows form prominent ridges; one massive granite unit underlies Old Rag Mountain. Clay-rich rocks, carbonate rocks (e.g. those in Shenandoah Valley west of the Park), and feldspar-rich rocks are broken down more rapidly and underlie lower elevations. Granite rocks, rich in feldspar, are especially susceptible to chemical alterations and become mantled with thick soils and saprolite. In the steep terrain of the Blue Ridge, the accumulations of weathered material become unstable. Heavy rains cause sheet washing and thick mantles of soil and saprolite slide or creep downhill toward streams. Streams erode colluvium and carry material further downhill. Long continued accumulation of colluvium in the upper reaches of streams or hollows promotes the sudden onset of landslides and debris flows during heavy rains.

Chemical weathering of rocks and mass wasting of a landscape are a response to the dominant weather regime. The present regime was initiated in Virginia at the end of the last ice age, about 11,000 years ago. The onset of these conditions may have dramatically altered the dominant landscape-defining processes in central Virginia. Carbon-14 dating of debris flows in central Virginia support this model for climate influence on slope stability.

Major storms that produce dramatic changes in the landscape occur in the central Appalachian Mountains about every 10-20 years. The catastrophic results of hurricane Camille in 1969 were the best documented. Debris flows and landslides killed 150 people and inflicted massive property damage in Nelson County, Virginia, just south of Shenandoah National Park. Similarly, storms and floods triggered major debris flows in the upper Potomac Basin in Virginia and West Virginia in November, 1985. The June 1995, storm that struck Madison County and other areas in and near Shenandoah National Park, Virginia, should be understood as a continuum in a process that has been ongoing for at least thousands of years.

The Meteorological Event

A storm which began on June 22, 1995, moved south through Virginia, bringing five days of moderate steady rains throughout Shenandoah National Park which saturated the soils (Table 1). The next low pressure front, with southeast tropical winds from the Atlantic Ocean, moved into the region on June 26. This front stalled against the mountains and was held in place by an upper southwest flow. Winds speeds during this period were low. Orographic lifting caused heavy rains, especially on the eastern side of the Blue Ridge. The storm cells were localized and rainfall amounts and timing varied greatly throughout the Park. The gage at Big Meadows received 8.5 inches of rain on June 27; based on anecdotal information, other Park areas reported greater rainfall amounts. The Graves Mill community just east of the Park in Madison County may have received as much as 24 inches of rain during this period. June rains brought the 1995 year-to-date precipitation total at Dickey Ridge to 27 inches, more than two and one-half times the five-year January to June year-to-date precipitation average and approximately equal to the 1991 and 1994 annual precipitation recorded at the site (Figure 4). A cold front finally entered the area on the 29th or 30th, bringing relief from the heavy rains in most areas.

Table 1. Rainfall collected at four weather stations located within or near Shenandoah National Park between June 22-29, 1995.

Date	Front Royal NOAA Station	Dickey Ridge NPS Station	Piney River NOAA Station	Big Meadows NPS Station
Thursday 6-22-95	0.0"	0.3"	0.5"	1.7"
Friday 6-23-95	0.7"	0.6"	1.3"	2.2"
Saturday 6-24-95	0.1"	0.4"	0.0"	0.4"
Sunday 6-25-95	0.0"	0.1"	0.4"	0.2"
Monday 6-26-95	2.2"	0.3"	2.2"	0.0"
Tuesday 6-27-95	0.4"	5.1"	3.9"	8.5"
Weds 6-28-95	0.2"	0.4"	0.2"	0.8"
Thursday 6-29-95	0.2"	0.0"	0.4"	0.7"
Totals	**3.8"**	**7.2"**	**8.9"**	**14.5"**

National Oceanic and Atmospheric Administration (NOAA) Data:

Device is a weighing bucket, measured from 0700 on the day listed to 0700 on the following day. There is another NOAA station at Big Meadows, but the data are considered unreliable.

National Park Service (NPS) Data:

Devices are a tipping bucket at Dickey Ridge and a Belfort Gauge at Big Meadows. Measurements are made at 2400 and listed on the chart for the day the rain actually fell.

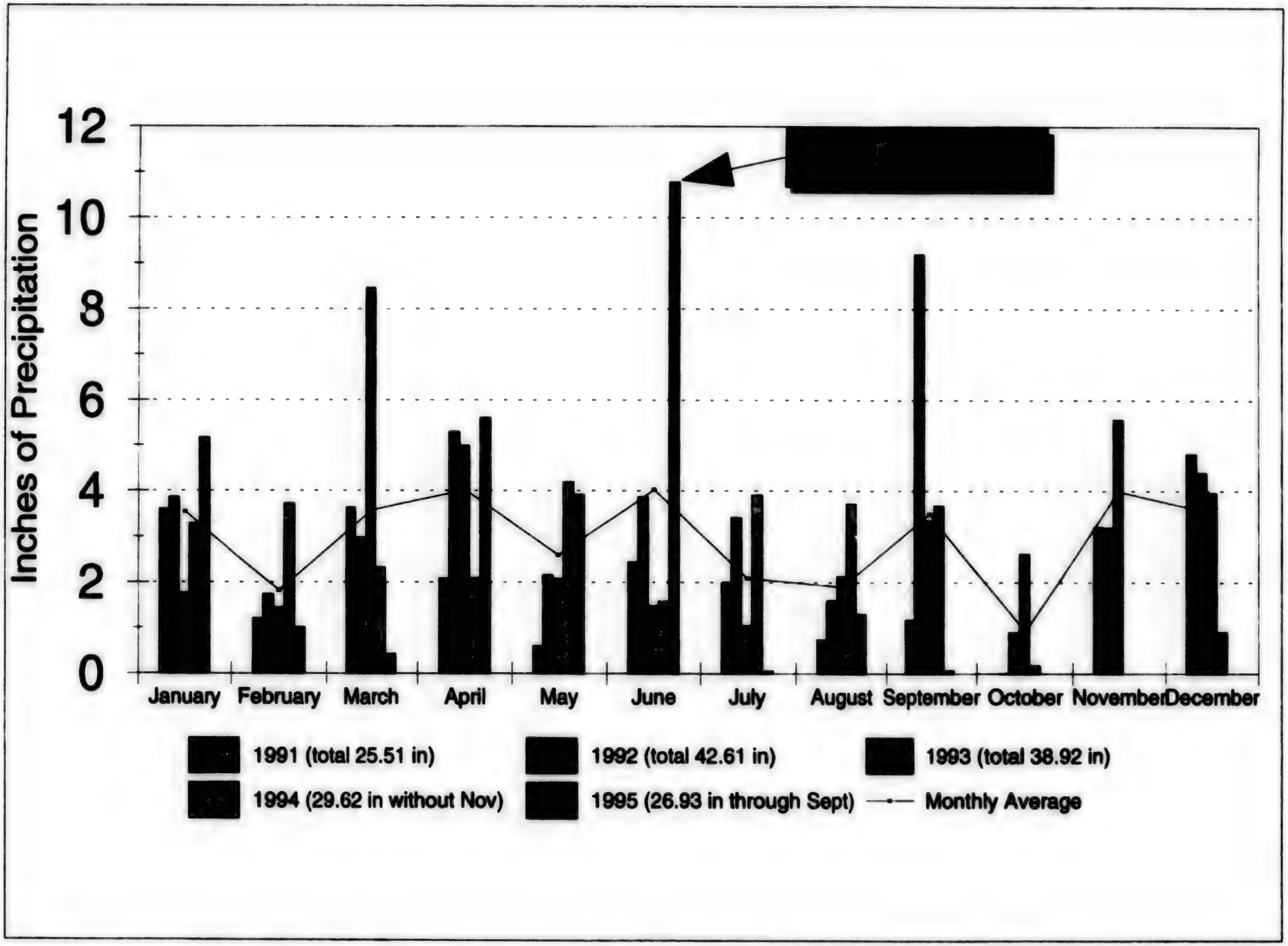

Figure 4. Average precipitation from 1991-1995 for rainfall collector located at Dickey Ridge air quality site.

Pre-Event Conditions

Staunton River

Terrestrial Vegetation

This drainage was characterized with a somewhat even-aged mature forest stand from the stream edge to the ridge tops although the headwaters of the Staunton contain a small stand of old growth forest. Chestnut oak (*Quercus prinus*) forests dominated the higher slopes and cove hardwood, yellow poplar (*Liriodendron tulipifera*), and eastern hemlock (*Tsuga canadensis*) forests occurred nearer the streams. These chestnut oak forests were slightly moister than those of other areas of the Park, and contained more mesic species such as northern red oak (*Quercus rubra*), striped maple (*Acer pensylvanicum*), and white oak (*Quercus alba*) and less of dry site species, such as pitch pine (*Pinus rigida*) and bear oak (*Quercus ilicifolia*). The forest types along the Staunton River were extremely rich in numbers of species. Plant species prevalent along sections of the Staunton River included yellow birch (*Betula lutea*), umbrella magnolia (*Magnolia tripetala*), sugar maple (*Acer saccharum*), blue cohosh (*Caulophyllum thalictroides*), large-flowered trillium (*Trillium grandiflorum*), broad beech fern (*Thelypteris hexagonoptera*), and New York fern (*Thelypteris noveboracensis*). This drainage begins at a relatively high elevation, and these higher elevations usually contain a large number of uncommon plant species.

A terrestrial long-term ecological monitoring (LTEM) site (2L129) is located in the middle portion of the Staunton River drainage. Data on site description, topography and landform, trees, shrubs, regeneration, and ground cover are collected from three plots at each terrestrial site[2].

Like the Rapidan area, gypsy moths began to have serious impacts upon the forest in the general area of the Staunton in 1989. Sustained defoliation and tree mortality continued through 1995. The amount of upper crown canopy losses due to the gypsy moth varies from 10 to 85 percent. Hemlock woolly adelgid (*Adelges tsugae*), an introduced Asian pest, was first discovered in the Park in 1988. By 1992, the hemlock adelgid was determined to be present in all Park hemlock stands. Since that time, the adelgid has caused steady decline and mortality of hemlock. Within riparian and surrounding moist areas of the Staunton River, hemlock woolly adelgid has caused crown thinning on up to 90 percent of hemlock individuals and overall tree mortality approaching 50 percent.

Stream Morphology

The Staunton River drainage is underlain by the Pedlar granite formation with the exception of a narrow zone of Old Rag granite near the confluence of the Rapidan River. The river had a well defined, somewhat meandering channel with alluvial bed and bank material and a forested riparian corridor. In 1993, as part of a fisheries research project, detailed measurements of the river's habitat, including number, size, and location of all pools, riffles, and cascades, dominant and subdominant substrate (nine size classes) in each habitat unit, and number of woody debris pieces (seven size categories), within almost the entire length (6,435.7 m) of the Staunton River were obtained. In the study, 321 pools and 264 riffles with an approximate area of 8,967 square meters and 16,540 square meters, respectively, were identified. Although sand and cobble were either the primary or secondary substrate in many of the habitat units, small and large gravel and boulders were also prevalent. Fine organics, clays, and silts were almost absent. The smallest size class (1-5 m in length and 5-10 cm in diameter) of woody debris accounted for approximately 55 percent of the total.

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[2] A detailed description of the data collected at terrestrial and aquatic LTEM sites is presented in Technical Report NPS/NRSHEN/NRTR-90/02, Shenandoah National Park Long-Term Ecological Monitoring System User Manuals.

Streamwater Chemistry

Pre-flood information concerning the hydrochemical condition of Shenandoah National Park streams and watersheds has been obtained through the Shenandoah Watershed Study (SWAS) program, managed by the University of Virginia. The objective of the SWAS program, in brief, has been to develop an understanding of processes that govern watershed ecosystem behavior and response to pollution and other disturbances (natural and unnatural) that occur in SNP. The June 1995 event is one such disturbance. Analysis of streamwater data through the SWAS program has included pH, acid-neutralization capacity (ANC), conductivity, the major anions and cations, aluminum, and silica. Co-location of streamwater sampling, discharge gauging, and precipitation sampling has allowed calculation of chemical fluxes and budgets for a number of SNP watersheds.

Staunton River is a primary site representing the granitic bedrock type and intermediate ANC (sometimes referred to as alkalinity) and pH class for SNP. Streamwater composition data collection on Staunton River has included quarterly sampling from 1987 till the event, at a site just upstream from the confluence with the Rapidan River. In 1992, weekly and storm event sampling was initiated with the installation of a discharge gauge (which was destroyed in the June 1995 flood) to record stream flow at a location near the quarterly sampling site. Synoptic surveys, involving spatially detailed sampling, have been conducted between spring 1992 and fall 1994 on multiple occasions in the watershed in support of basin-wide fish habitat and population surveys (Figure 5). Data for a number of high-flow events, some of which indicate episodic acidification, are also available.

Figure 6 presents multiple years of streamwater composition data collected at the quarterly sampling site on Staunton River. Weekly pH and ANC (alkalinity) values are shown in Figure 7 and Figure 8, respectively. Concentrations are typical of base-flow conditions in streams of the Blue Ridge Mountains that are associated with granitic bedrock.

The strong-acid anions (sulfate, chloride, and nitrate) are primarily derived from atmospheric sources. Streamwater sulfate concentrations ranged between about 40 and 60 μeq/L. This is substantially less than expected for the level of atmospheric sulfur deposition in SNP, indicating relatively strong sulfur retention in the Staunton River watershed. Streamwater chloride concentrations, ranging between about 20 and 30 μeq/L, were consistent with concentrations expected for atmospheric chloride deposition. Streamwater nitrate concentrations increased beginning about 1990. Previous streamwater concentrations were near zero, reflecting ecosystem demand for nitrogen as a limiting nutrient. The increase in nitrate concentrations to about 10 μeq/L was apparently due to disruption of the nitrogen cycle following forest defoliation by the gypsy moth.

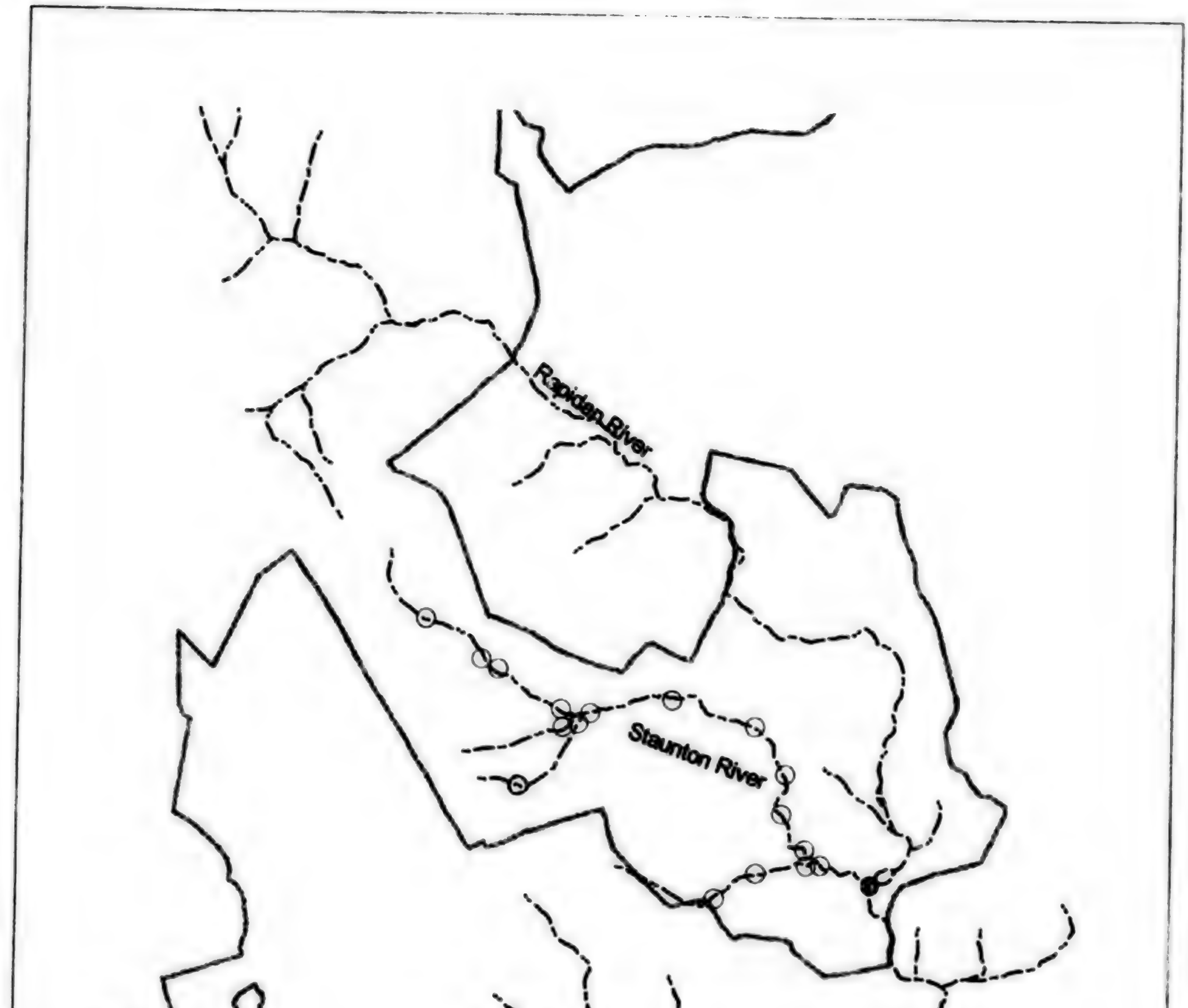

Figure 5. Streamwater composition sampling sites on the Staunton River.

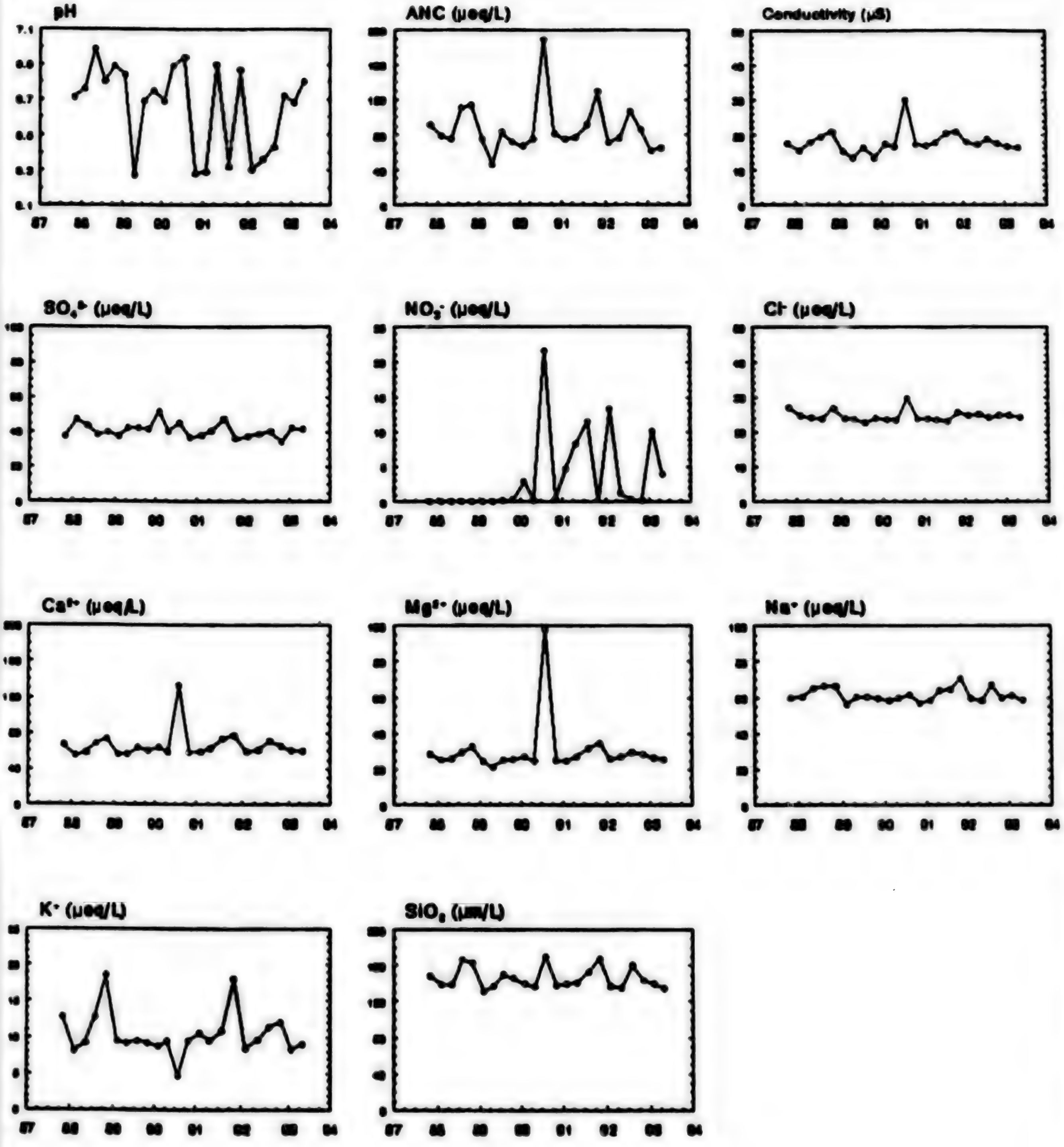

Figure 6. Quarterly streamwater composition data for the Staunton River, 1987-1993.

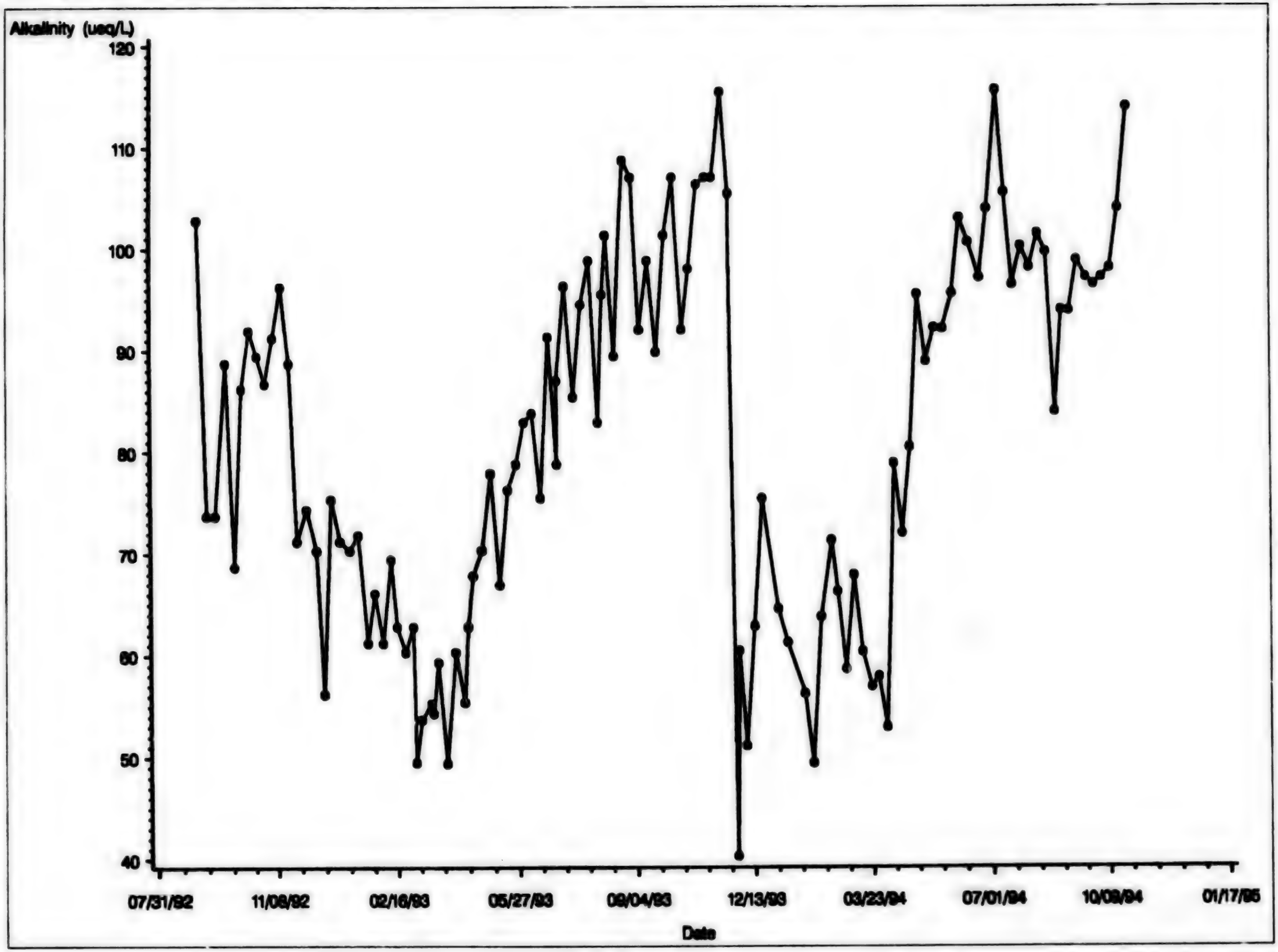

Figure 7. Weekly alkalinity (ANC) values for the Staunton River, 1992-1994.

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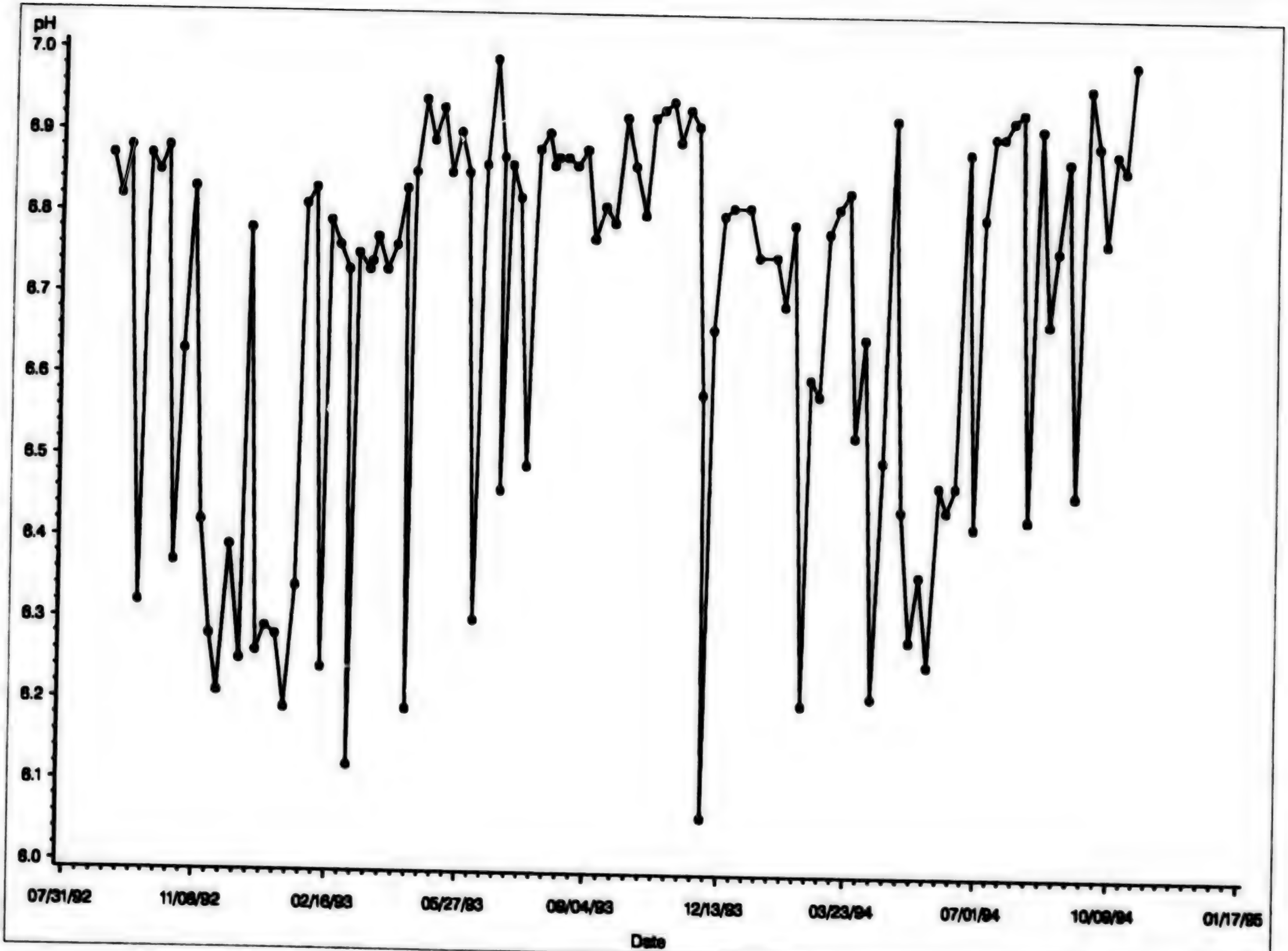

Figure 8. Weekly pH values for the Staunton River, 1992-1994.

15

The base cations (calcium, magnesium, sodium, and potassium) and silica are primarily derived from watershed sources. The concentrations of these solutes reflected the composition and weathering rates of surficial rock and soil. The concentrations of base cations and silica in Staunton River can be described as generally intermediate relative to the range of concentrations observed in SNP streams.

ANC in Staunton River ranged between about 50 and 100 μeq/L, indicating moderate sensitivity to acidification. This ANC range is reflected in pH, which ranged between about 6.3 and 7.0, a suitable range for most aquatic fauna. Somewhat more extreme values of ANC and pH occurred during storm-flow episodes, when concentrations of sulfate and nitrate increased relative to base cations. Episodic ANC concentrations of 35 μeq/L and pH values of 6.0 have been observed. Moderately elevated levels of dissolved aluminum also occurred during these episodes, with concentrations observed up to about 30 μg/L (inorganic monomeric Al).

Macroinvertebrate

This cool, rocky stream was typical of many streams in the Appalachian system and had ample oxygenation and habitat diversity. The dynamics of the macroinvertebrate community were based on the processing of autumn leaf input, the collecting/ gathering of finer particles, and predation.

Two aquatic LTEM sites were present on the Staunton River and have been surveyed since 1986 (see footnote 2). One site (2L306) was far upstream just below the headwater seep; the second site (2L307) was located near the Park boundary above the confluence with the Rapidan. Invertebrate sampling was done twice each year, in late spring and early fall. One qualitative and three quantitative samples were taken during each site visit. A summary of the numbers of various taxa collected from 1986 through 1994 at the two LTEM sites is presented in Tables 2 and 3. In addition to the invertebrate samples, data were obtained on simple water chemistry parameters, discharge, and habitat descriptors.

In 1995, a change was made to the aquatic LTEM protocols; the time-consuming habitat measurements were discontinued to allow more sites to be sampled and provide more integration with other water related projects. Ten sites were visited and sampled in the Staunton River drainage in May 1995, before the event (Figure 9). These included the two LTEM sites, four SNP fish survey transects, and four SWAS sites. The specimens collected have not yet been identified, but they will provide solid pre-event data for the spring invertebrate community to compare with similarly-timed samples taken in the future.

Table 2. Summary of Aquatic Macroinvertebrate Data, 1986-1994, Upper Staunton River LTEM site 2L306. Numbers are composited from three quantitative and one qualitative sample; 1986 and 1987 data also included reared and adult aerial samples. For each collection the table lists the number of individuals identified and unique "taxa." The number of definitive taxa across the range of taxonomic hierarchy (from Phylum to Species) are also listed for aggregative comparisons (e.g., 125 "taxa" and 1 Phylum indicates that all 125 kinds of organisms were from a single Phylum).

Season	Year	Individuals	"Taxa"	Phyla	Classes	Orders	Families	Genera	Species
Spring	1987	97	35	1	2	7	24	30	14
	1988	108	25	1	1	6	19	23	3
	1989	297	40	2	4	9	27	33	7
	1990	232	39	1	2	8	28	32	8
	1991	217	38	1	2	8	27	34	8
	1992	88	32	1	2	7	23	28	6
	1993	888	49	2	3	10	29	36	10
	1994	690	52	3	5	10	27	37	8
Fall	1986	168	30	1	2	8	23	27	9
	1988	224	32	1	2	8	23	27	6
	1989	179	39	2	2	7	29	33	10
	1990	159	40	1	2	8	29	31	10
	1991	508	41	2	3	10	31	32	7
	1992	403	34	1	2	7	25	29	7
	1993	225	32	2	3	9	21	25	9
	1994	414	40	1	1	7	28	34	8

Table 3. Summary of Aquatic Macroinvertebrate Data, 1986-1994, Lower Staunton River LTEM site 2L307. Numbers are composited from three quantitative and one qualitative sample; 1986 and 1987 data also included reared and adult aerial samples. For each collection the table lists the number of individuals identified and unique "taxa." The number of definitive taxa across the range of taxonomic hierarchy (from Phylum to Species) are also listed for aggregative comparisons (e.g., 125 "taxa" and 1 Phylum indicates that all 125 kinds of organisms were from a single Phylum).

Season	Year	Individuals	"Taxa"	Phyla	Classes	Orders	Families	Genera	Species
Spring	1987	185	41	1	2	8	22	36	18
	1988	217	35	1	2	9	23	28	7
	1989	761	41	3	4	10	28	33	9
	1990	844	44	2	2	8	29	40	11
	1991	928	48	3	4	11	34	38	9
	1992	615	39	1	1	7	26	37	10
	1993	590	53	3	4	9	31	39	11
	1994	1318	55	4	4	8	33	49	14
Fall	1986	353	34	1	2	8	26	30	11
	1988	222	32	2	3	9	21	25	8
	1989	252	39	2	3	9	27	31	9
	1990	332	40	2	3	11	29	30	8
	1991	438	42	2	3	11	26	30	8
	1992	303	43	2	2	9	27	37	10
	1993	1395	54	4	5	13	34	39	10
	1994	1348	50	5	7	11	32	37	9

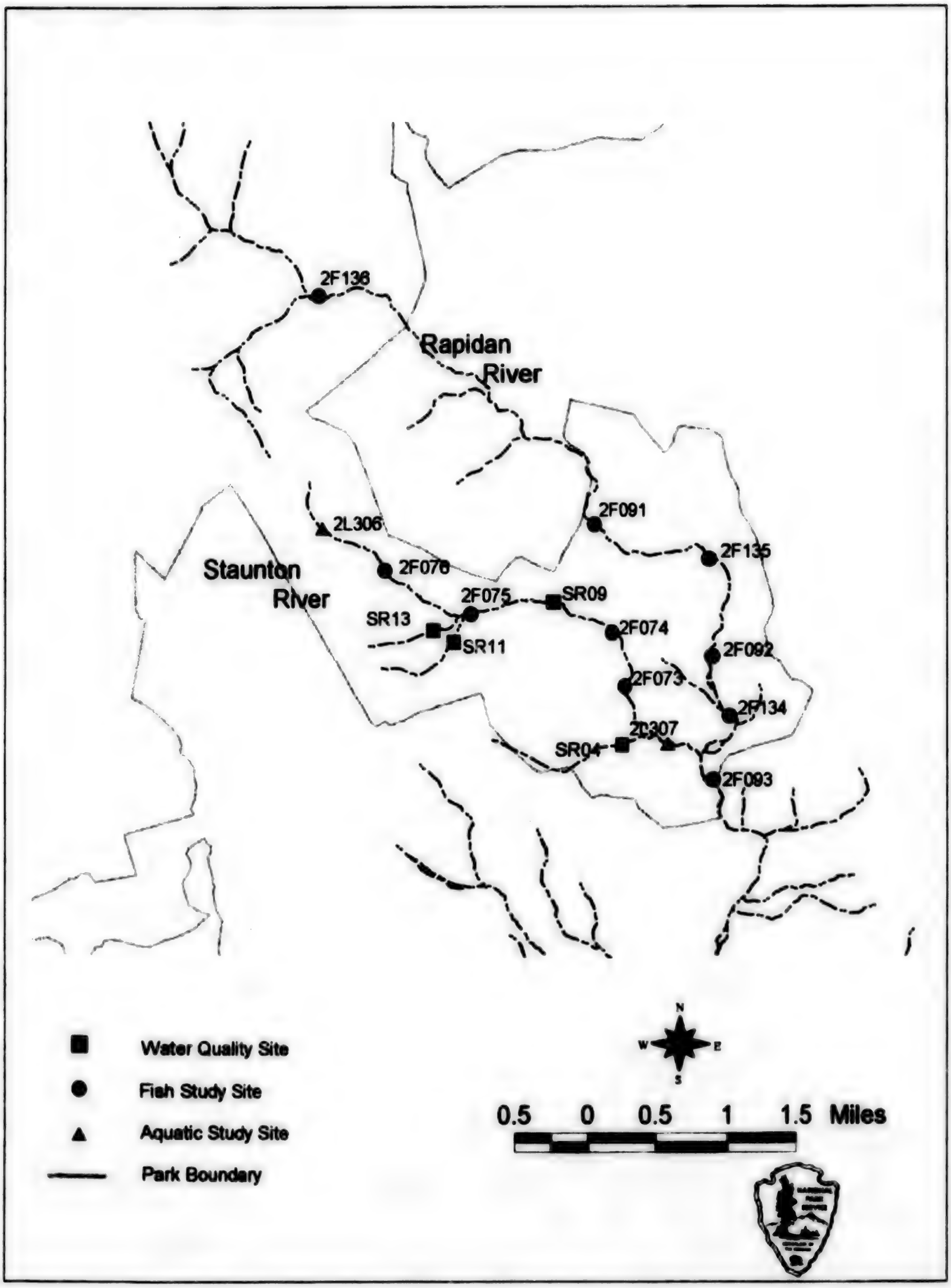

Figure 9. Staunton River macroinvertebrate, fish and water quality sites. Macroinvertebrates were sampled at all identified sites in May 1995.

Salamanders

Based on May 1995 surveys, the streamside salamander fauna in the lower mainstem reaches of the Staunton River in SNP consisted of the Virginia seal salamander (*Desmognathus monticola jeffersoni*), northern spring salamander (*Gyrinophilus porphyriticus porphyriticus*), and the northern two-lined salamander (*Eurycea bislineata bislineata*). Additionally, the northern dusky salamander (*Desmognethus fuscus fuscus*) occurred in a seepage tributary near where the discharge gauge had been located.

Fish

The Staunton River, a major tributary to the Rapidan River, was a catch-and-release brook trout stream. Riparian cover throughout the drainage ranged from 90 to 100 percent. Fish cover was abundant due to many large undercut rocks, root masses, and woody material in the stream. There were many large boulders in the stream with large plunge pools at their bases. The Staunton had a somewhat even pool to riffle ratio, making it excellent habitat for brook trout (*Salvelinus fontinalis*). Approximately 5.6 km of the stream in the Park could be fished.

As part of a research project through Virginia Tech, fish surveys of almost the entire length of the river were conducted in the spring and fall of 1993 and 1994 and in the spring of 1995. Detailed information was collected on all fish species, including population estimates, age structure, length, weight, condition factor, and annual production. In the spring of 1995, rosyside dace (*Clinostomus funduloides*) were found from the confluence of the Rapidan River to approximately 500 meters upstream and their numbers were estimated at 1,256 per hectare. Torrent suckers (*Thoburnia rhothoeca*) were found from the confluence of the Rapidan River to approximately 255 meters upstream and their numbers were estimated to be 740 per hectare. Throughout the entire stream length, the density of brook trout and blacknose dace (*Rhinichthys atratulus*) was estimated at approximately 1600 and 400 per hectare, respectively, in the spring of 1995. Estimated densities during 1993, 1994, and 1995 for brook trout and blacknose dace are presented in Figure 10 and Figure 11, respectively.

There were also five SNP fish survey transects, 100 meters in length each, along the Staunton River which had been sampled in seven of the past 13 years (see Figure 9). Prior to the event, the transects were surveyed most recently on July 13 and 14, 1993. Over the years, brook trout populations have exhibited a very good age structure with the exception of a slightly depressed young-of-year (YOY) age class in some transects (Table 4). The total numbers of brook trout have fluctuated slightly over the past sampling seasons but have consistently been within limits of natural variation. In the 1993 survey, American eel, blacknose dace, and torrent suckers were also collected.

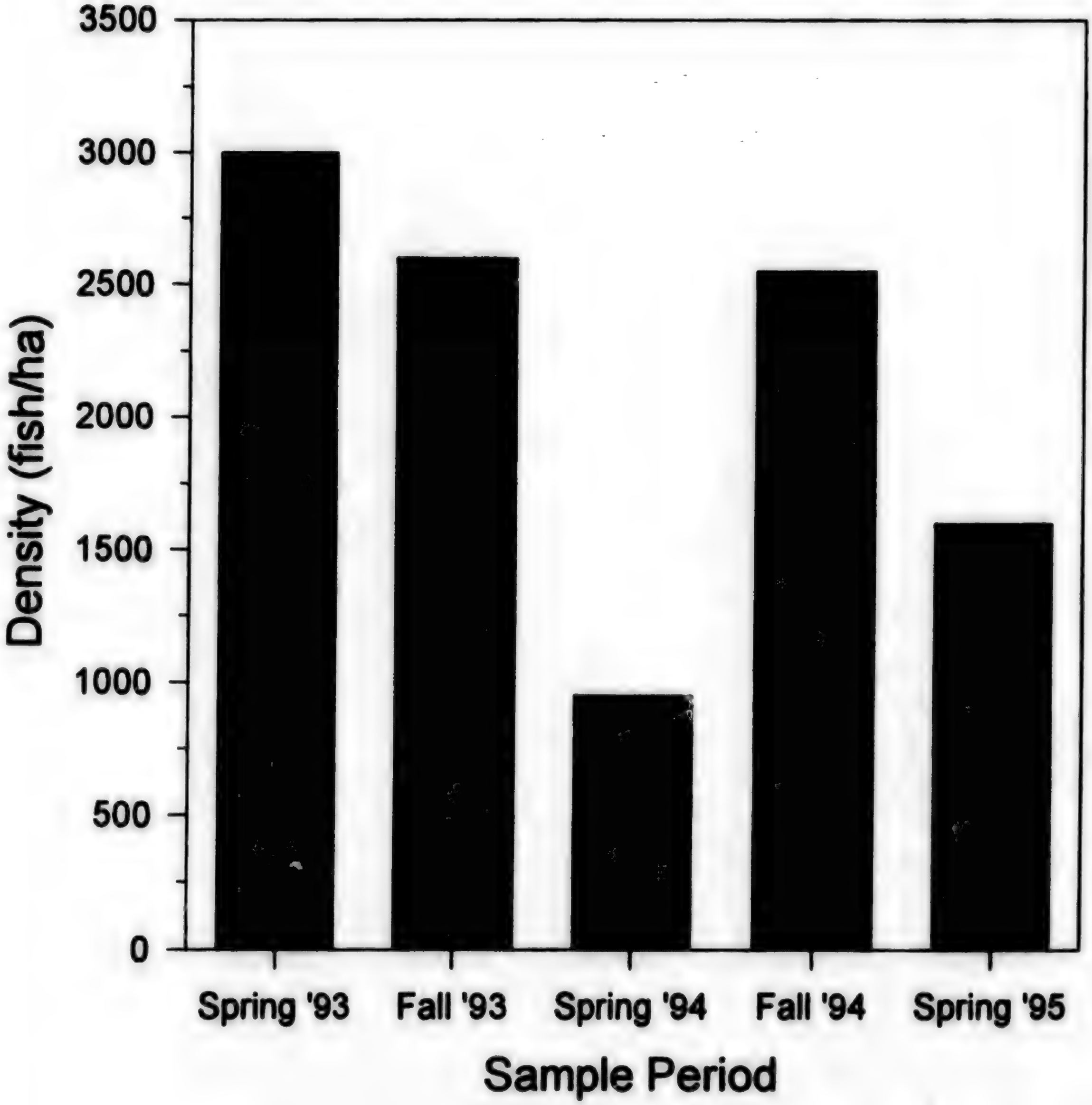

Figure 10. Estimated density of brook trout in the Staunton River, 1993-1995.

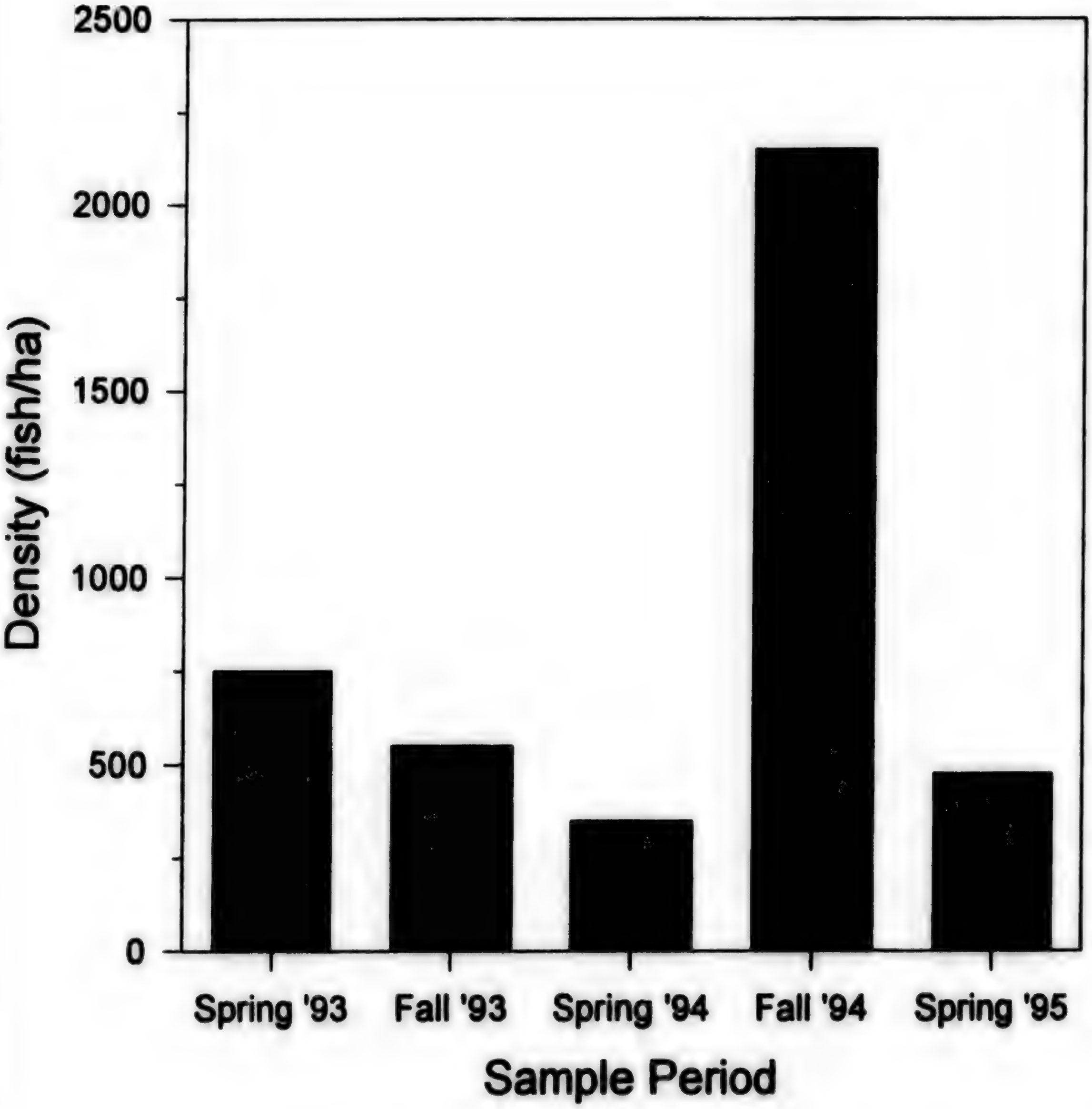

Figure 11. Estimated density of blacknose dace in the Staunton River, 1993-1995.

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Table 4. Brook trout density, by age class, in the Staunton River, 1983-1993 in five 100-meter fish survey transects. Transect numbers are in sequential order from bottom to top of the watershed.

Transect Number	Age Class (0-3)	Sample Years													
		1983		1984		1985		1987		1989		1991		1993	
		Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total
72 (Bottom)	Age 0	11	15.3	31	47.0	108	87.1	45	77.6	65	63.7	46	49.5	22	32.4
	Age 1	45	62.5	20	30.3	14	11.3	4	6.9	23	22.5	34	36.6	25	36.8
	Age 2	16	22.2	13	19.7	2	1.6	7	12.1	14	13.7	13	14.0	20	29.4
	Age 3	0	0.0	2	3.0	0	0.0	2	3.4	0	0.0	0	0.0	1	1.5
	Total	72		66		124		58		102		93		68	
73	Age 0	12	10.3	14	19.2	97	63.0	32	39.5	25	32.9	44	33.6	13	18.6
	Age 1	86	74.1	45	61.6	42	27.3	23	28.4	46	60.5	55	42.0	34	48.6
	Age 2	18	15.5	14	19.2	15	9.7	25	30.9	5	6.6	32	24.4	23	32.9
	Age 3	0	0.0	0	0.0	0	0.0	1	1.2	0	0.0	0	0.0	0	0.0
	Total	116		73		154		81		76		131		70	
74	Age 0	9	9.0	NS	0.0	60	65.2	40	65.6	39	44.3	46	45.1	30	30.0
	Age 1	72	72.0	NS	0.0	22	23.9	8	13.1	45	51.1	44	43.1	46	46.0
	Age 2	19	19.0	NS	0.0	10	10.9	13	21.3	3	3.4	12	11.8	24	24.0
	Age 3	0	0.0	NS	0.0	0	0.0	0	0.0	1	1.1	0	0.0	0	0.0
	Total	100		0		92		61		88		102		100	
75	Age 0	7	6.1	NS	0.0	64	49.6	30	42.9	28	24.1	41	36.9	22	31.0
	Age 1	93	81.6	NS	0.0	52	40.3	10	14.3	79	68.1	62	55.9	24	33.8
	Age 2	12	10.5	NS	0.0	13	10.1	30	42.9	9	7.8	8	7.2	25	35.2
	Age 3	2	1.8	NS	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Total	114		0		129		70		116		111		71	
76 (Top)	Age 0	16	12.2	15	25.9	53	51.5	36	44.4	21	22.8	28	37.3	74	66.1
	Age 1	94	71.8	34	58.6	40	38.8	25	30.9	53	57.6	37	49.3	24	21.4
	Age 2	21	16.0	9	15.5	10	9.7	18	22.2	17	18.5	10	13.3	13	11.6
	Age 3	0	0.0	0	0.0	0	0.0	2	2.5	1	1.1	0	0.0	1	0.9
	Total	131		58		103		81		92		75		112	

	Age Class (0-3)	Sample Years													
		1983		1984		1985		1987		1989		1991		1993	
		Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total
Stream Summaries by Age Class	Age 0	55	10.3	60	30.5	382	63.5	183	52.1	178	37.6	205	40.0	161	38.2
	Age 1	390	73.2	99	50.3	170	28.2	70	19.9	246	51.9	232	45.3	153	36.3
	Age 2	86	16.1	36	18.3	50	8.3	93	26.5	48	10.1	75	14.6	105	24.9
	Age 3	2	0.4	2	1.0	0	0.0	5	1.4	2	0.4	0	0.0	2	0.5
Total Fish Count for Transect(s)		533		197		602		351		474		512		421	

NS = Not Shocked

Rapidan River

Terrestrial Vegetation

For the Rapidan River drainage, the forest was of similar composition and age as that of the Staunton River, with slightly moister than normal chestnut oak forests on the higher slopes and cove hardwood, yellow poplar, and hemlock forests nearer the streams. The forest types along the Rapidan River were also extremely rich in numbers of species. This drainage also begins at a high elevation area containing a large number of uncommon plant species. Four terrestrial LTEM sites, 2L104, 2L121, 2L123, and 2L311, are located in the drainage.

Gypsy moths (*Lymantria dispar*) arrived in the Park in 1982 and began to have serious impacts upon the forest in the general area of the Rapidan in 1989. Sustained defoliation and tree mortality continued through 1995. The amount of upper crown canopy losses due to the gypsy moth were 10-85 percent.

Of great importance to the Rapidan riparian area and surrounding moist areas, was the impact to eastern hemlock from hemlock woolly adelgid (*Adelges tsugae*). Since initial establishment in the Park, the adelgid has caused steady decline and mortality of hemlock, approaching 50 percent tree losses in the Rapidan system.

Stream Morphology

The Rapidan River originates in a broad area of metamorphosed Catoctin basalt, flows across a larger region of Pedlar granite gneiss, and then crosses a small area of Old Rag granite prior to exiting the Park. The Rapidan has a large drainage area and low gradient. Similar to the Staunton River, the Rapidan had a well defined, somewhat meandering channel with alluvial bed and bank material and a forested riparian corridor.

Streamwater Chemistry

The only available streamwater chemistry for the Rapidan River was obtained during Park-wide stream surveys conducted in the 1980s. The observed concentrations were typical of Blue Ridge streams with watersheds underlain by a mixture of granitic and basaltic rocks of the Pedlar, Old Rag, and Catoctin formations. Compared with SNP streams associated with silici-clastic bedrock, total ion concentrations and ANC values in the Rapidan River were relatively high, yet similar to ion concentrations in the Staunton River. Streamwater ANC, for example, generally ranged between 50 and 100 μeq/L, a range that does not indicate extreme sensitivity to acidic deposition.

Macroinvertebrates

There are no aquatic LTEM sites on the Rapidan River. The pre-event invertebrate community structure is unknown.

Salamanders

This area had not been inventoried. However, given the distribution of the streamside salamander populations in SNP, most of the species noted for the Staunton River probably also occurred in the Rapidan River.

Fish

The lower Rapidan River is a transitional mountain/piedmont stream which had a semi-enclosed tree canopy that provided moderate (65-85 percent) amounts of riparian cover. Fish cover throughout the lower portion was also moderate, mainly found in the form of large deep pools since the riffles were shallow. The Rapidan River was used by many visitors as a swimming area.

The Rapidan River was managed as a catch-and-release trout stream and, due to its structurally diverse habitat and constant year-round flow, may have been the best trout stream in the Park. Six SNP fish survey transects located on the Rapidan have followed a two-year sampling interval since 1983 and, prior to the event, were most recently sampled on July 15 and 19, 1993 (see Figure 9). Over the years, the brook trout population age structure has been very good to excellent and total numbers have remained consistent (Table 5). Most noteworthy is the number of age-3 brook trout that this stream had supported. In 1993, eleven other species of fishes were collected, mostly in the lower two transects.

North Fork Moormans River

Terrestrial Vegetation

The even-aged forests of the North Fork Moormans River watershed were dominated on the upper slopes by chestnut oak and associated species were more indicative of dry site forest components. Common tree species, in addition to chestnut oak, include black birch (*Betula lenta*), sassafras (*Sassafras albidum*), black gum (*Nyssa sylvatica*), black oak (*Quercus velutina*), northern red oak (*Quercus rubra*), and pitch pine (*Pinus rigida*). Woody understory species included maple-leaf viburnum (*Viburnum acerifolium*), deerberry (*Gaylussacia baccata*), blueberries (*Vaccinium spp.*), mountain laurel (*Kalmia latifolia*), minnie-bush (*Menziesia pilosa*), American chestnut (*Castanea dentata*), bear oak (*Quercus ilicifolia*), and flowering dogwood (*Cornus florida*). Herbaceous and diminutive woody species included hay-scented fern (*Dennstaedia punctiloba*), rose twisted-stalk (*Streptopus roseus*), wild sarsaparilla (*Aralia nudicaulis*), spotted wintergreen (*Chimaphila maculata*), bracken fern (*Pteridium aquilinum*), and whorled loosestrife (*Lysimachia quadrifolia*).

Closer to the river, cove hardwood, yellow poplar, and hemlock forests predominated. Common tree species included yellow poplar (*Liriodendron tulipifera*), American ash (*Fraxinus americana*), slippery elm (*Ulmus rubra*), eastern hemlock (*Tsuga canadensis*), red maple (*Acer rubrum*), and basswood (*Tilia americana*). American beech (*Fagus grandifolia*) and sycamore (*Platanus occidentalis*) bordered the stream in places. Understory species included striped maple (*Acer pensylvanicum*), spicebush (*Lindera benzoin*), American hophornbeam (*Ostrya virginiana*), wild hydrangea (*Hydrangea arborescens*), and alternate-leaved dogwood (*Cornus alternifolia*). Tag alder (*Alnus serrulata*) was sometimes found along the stream. Tree-of-heaven (*Ailanthus*

Table 5. Brook trout density, by age class, in the Rapidan River, 1983-1993 in five 100-meter fish survey transects. Transect numbers are listed in order from bottom to top of the watershed.

Transect Number	Age Class (0-3)	Sample Years											
		1983		1985		1987		1989		1991		1993	
		Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total
93 (Bottom)	Age 0	4	26.7	23	79.3	13	92.9	8	61.5	64	75.3	20	52.6
	Age 1	2	13.3	3	10.3	0	0.0	3	23.1	15	17.6	12	31.6
	Age 2	9	60.0	2	6.9	1	7.1	2	15.4	6	7.1	6	15.8
	Age 3	0	0.0	1	3.4	0	0.0	0	0.0	0	0.0	0	0.0
	Total	15		29		14		13		85		38	
134	Age 0	15	21.4	39	79.6	15	75.0	16	69.6	96	77.4	22	40.7
	Age 1	39	55.7	5	10.2	0	0.0	4	17.4	20	16.1	22	40.7
	Age 2	15	21.4	4	8.2	2	10.0	3	13.0	6	4.8	9	16.7
	Age 3	1	1.4	1	2.0	3	15.0	0	0.0	2	1.6	1	1.9
	Total	70		49		20		23		124		54	
92	Age 0	9	10.5	70	71.4	39	73.6	23	57.5	60	41.4	32	36.4
	Age 1	31	36.0	5	5.1	3	5.7	9	22.5	38	26.2	23	26.1
	Age 2	42	48.8	16	16.3	6	11.3	5	12.5	40	27.6	29	33.0
	Age 3	4	4.7	7	7.1	5	9.4	3	7.5	7	4.8	4	4.5
	Total	86		98		53		40		145		88	
135	Age 0	21	16.8	54	58.1	41	51.9	15	65.2	29	33.0	14	16.9
	Age 1	51	40.8	10	10.8	12	15.2	3	13.0	30	34.1	26	31.3
	Age 2	44	35.2	23	24.7	18	22.8	3	13.0	28	31.8	36	43.4
	Age 3	9	7.2	6	6.5	8	10.1	2	8.7	1	1.1	7	8.4
	Total	125		93		79		23		88		83	
91	Age 0	18	24.0	81	84.4	45	77.6	26	38.2	45	41.3	45	44.6
	Age 1	40	53.3	6	6.3	1	1.7	37	54.4	33	30.3	26	25.7
	Age 2	16	21.3	9	9.4	10	17.2	4	5.9	24	22.0	30	29.7
	Age 3	1	1.3	0	0.0	2	3.4	1	1.5	7	6.4	0	0.0
	Total	75		96		58		68		109		101	
136 (Top)	Age 0	NS	0	43	42.2	25	37.9	11	8.5	28	22.0	42	35.9
	Age 1	NS	0	43	42.2	20	30.3	105	80.8	77	60.6	51	43.6
	Age 2	NS	0	16	15.7	20	30.3	12	9.2	22	17.3	24	20.5
	Age 3	NS	0	0	0.0	1	1.5	2	1.5	0	0.0	0	0.0
	Total	0		102		66		130		127		117	

	Age Class (0-3)	Sample Years											
		1983		1985		1987		1989		1991		1993	
		Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total
Stream Summaries by Age Class	Age 0	67	18.1	310	66.4	178	61.4	99	33.3	322	47.5	175	36.4
	Age 1	163	43.9	72	15.4	36	12.4	161	54.2	213	31.4	160	33.3
	Age 2	126	34.0	70	15.0	57	19.7	29	9.8	126	18.6	134	27.9
	Age 3	15	4.0	15	3.2	19	6.6	8	2.7	17	2.5	12	2.5
Total Fish Count for Transect(s)		371		467		290		297		678		481	

NS = Not Shocked

altissima), an introduced species, was becoming prevalent in certain areas. Herbaceous species included jack-in-the-pulpit (*Arisaema triphyllum*), Christmas fern (*Polystichum acrostichoides*), maiden hair fern (*Adiantum pedatum*), Virginia waterleaf (*Hydrophyllum virginianum*), bloodroot (*Sanguinaria canadensis*), lopseed (*Phryma leptostachya*), wood nettle (*Laportea canadensis*), and horse balm (*Collinsonia canadensis*).

Four terrestrial LTEM sites, 3L110, 3L118, 3L119, and 3L120, are located in the North Fork Moormans River watershed. Site 3L118 is in a hemlock forest cover type and site 3L110 is located close to the river.

Gypsy moths arrived at the North Fork in 1990 and had serious forest canopy effects through 1995. Upper crown mortality was higher than the central section of the Park, perhaps approaching 25-80 percent. This did not mean the creation of bare ground, but rather allowed the advanced regeneration and understory species to be released, including maples, yellow-poplar, occasional beech, as well as some white and red oaks.

Hemlock woolly adelgid has had similar impacts upon the North Fork as elsewhere, virtually all hemlock have some crown impacts, and tree mortality approaches 50 percent.

Stream Morphology

Compared to the Staunton and Rapidan, the North Fork Moormans River has a larger drainage area, higher flows, lower gradient, and a better developed valley bottom. The watershed is mostly underlain by Catoctin volcanic basalts with well developed foliation striking north, parallel to the stream, and dipping downslope to the east. The rock weathers to red clay with very little quartz; saprolite is prominent. The upper area of the ridge on the western side of the watershed is underlain by Chilhowee silici-clastics.

Streamwater Chemistry

Streamwater chemistry for the North Fork Moormans River was obtained during Park-wide stream surveys conducted in the 1980s. The observed concentrations are generally typical of Blue Ridge streams associated with basaltic rocks of the Catoctin formation. Compared with SNP streams associated with other bedrock types, total ion concentrations and ANC values in most of the North Fork Moormans River watershed were relatively high. Streamwater ANC values, for example, were above 100 μeq/L. These concentrations indicated high weathering rates in watershed rocks, high base saturation in watershed soils, and a lack of soil and water sensitivity to acidic deposition.

Different conditions were observed in the part of the watershed that is underlain by the silici-clastic Chilhowee formations. The available data for tributaries with watershed areas that are partly underlain by the Chilhowee indicated lower total ion concentrations and lower ANC. For example, ANC concentrations of less than 50 μeq/L have been measured for Big Branch and the tributary below Blackrock Gap; it is probable that ANC values of near 0 μeq/L were present in the upper reaches of these tributaries. These areas contrasted sharply with the rest of the North Fork Moormans watershed with respect to weathering rates, base supply in soils, and sensitivity to acidification.

A study of the effects of gypsy moth (*Lymantria dispar*) defoliation on aquatic biota of headwater streams during 1991 and 1992 included two sample sites in this drainage; about 1.8 km upstream on an unnamed tributary flowing from the Blackrock Gap area, and about 800 meters upstream on Shop Run. Both areas were severely defoliated (75 percent) during 1991. Data on water temperature, stream discharge, pH, dissolved oxygen, alkalinity, hardness, conductivity, and nutrients were collected between April 1991 and March 1992. The annual mean, maximum daily mean, and minimum daily mean water temperatures (°C) were 11.2, 20.6, 0.4 and 11.2, 19.5, 1.3 for the unnamed tributary on Shop Run sites, respectively. Stream discharge (cubic meters per second) ranged between 0.0016 (10/12/91) - 0.0449 (3/12/92) and 0.0004 (10/26/91) - 0.04 (1/10/92) for the unnamed tributary and Shop Run, respectively. The streamwater pH of both streams generally fluctuated between 6.1 and 6.9. Alkalinity (mg/L $CaC0_3$) values at the unnamed tributary site ranged from -4.416 on 5/29/91 to 5.12 on 4/13/91; most values were between 0.5 and 1.7. For Shop Run, alkalinity values ranged from 0.6 on 3/12/91 to 3.05 on 10/26/91.

Macroinvertebrates

There were no aquatic LTEM sites on the North Fork Moormans River. The pre-event invertebrate community structure is relatively unknown. However, as part of the study mentioned in the previous section, macroinvertebrates were sampled in mid-May 1991 and 1992 from three riffles in each of the two tributaries. For the unnamed tributary, the mean total abundance per 0.1 square meter sample was 428.0 and 395.7 in 1991 and 1992, respectively; taxa richness was 37 and 30 in 1991 and 1992, respectively. In Shop Run, the mean total abundance per 0.1 sq meter sample was 185.7 and 194.0 in 1991 and 1992, respectively; taxa richness was 27 and 29 in 1991 and 1992, respectively. The three most abundant taxa in 1991 at the unnamed tributary site were Chironomidae, Leuctra, and Chloroperidae; in 1992, Habrophleboides replaced Chloroperidae as the third most abundant taxa. For both years, Chironomidae and Chloroperidae were the two most abundant taxa at Shop Run. The study also examined the secondary production and growth of the different macroinvertebrate functional feeding groups.

Salamanders

This area had not been inventoried. However, given the distribution of the streamside salamander populations in SNP, the same species noted for the Staunton River should have also occurred in the North Fork Moormans.

Fish

Prior to the flood, the North Fork Moormans River was a heavily fished catch-and-release trout stream. Lennon (1961) stated "the North Fork was perhaps the most marginal trout stream in the Park. Of five Park streams surveyed annually from 1955 to 1959, the Moorman's had the least number of brook trout per area. Warmer than average water temperatures, competition from introduced populations of rainbow trout and pressure from anglers were the leading implications."

The North Fork Moormans River has a low-gradient and riparian cover ranged from about 75 percent at the lower portion to 85 percent or greater at the top of the drainage. The transition point for this break was in the vicinity of Big Branch. Fish cover was moderate at the lower section and increased to abundant as one traveled upstream. The North Fork Moormans River had a stair-stepped even grade throughout the stream which supported an abundant brook trout population. This area was heavily used by people living in the Charlottesville area for fishing and other recreation. The headwaters and one other large section of the watershed along the upper stream area are located on private land.

Approximately 4.8 km of the stream within the Park could be fished. Five SNP fish survey transects established in 1983 have followed a two-year sampling interval and, prior to the event, were most recently sampled on June 14, 15, and 19, 1995 (Figure 12). Brook trout have exhibited a very good to excellent population age (including age-3) structure and total numbers have generally remained high (Table 6). In the June 1995 surveys, twelve other species of fishes were present, including a breeding population of brown trout (*Salmo trutta*). No random trout were present

Big Branch, an approximately one mile long tributary of the North Fork Moormans River that was also managed as a catch-and-release trout fishery, contained three SNP fish survey transects. These transects have been sampled every two years since 1982, and, prior to the event, were last sampled on June 19 and 20, 1995. With the exception of slightly depressed YOY age class in some transects, particularly the bottom section, this stream had a fairly good brook trout population age structure. Typical of many streams, trout in the upper transect (often the mid to upper section of the stream) had the best population structure and highest abundance.

Mt. Marshall Area

The Mt. Marshall area affected by the flooding event is substantially different from other affected Park sites. No significant drainages are present in the area. Topography is characterized by a very steep and rugged, rocky grade in Pedlar formation on the west side of Skyline Drive to the Park boundary, an elevation change of 1000 feet in approximately 1/2 mile. A few small drainages exist with seasonally intermittent streams created by small seeps and surface runoff. Vegetation is second and third growth forest with primarily chestnut oak and red oak. The canopy is generally closed with very little gypsy moth impact to the oak forest.

On the east side, a relatively moderate (but rugged and rocky) grade to Park boundary exists within the Hogwallow Flat area. Geology is predominantly Catoctin formation. A few small drainages exist and are slightly more substantial than those found on the west side. Vegetation is second and third growth forest with primarily chestnut oak and red oak in higher elevations and tulip poplar, red oak, white ash, and red maple in lower elevations and cove sites. Oak mortality resulting from gypsy moth infestation in the late 1980s is extensive in some areas with large pockets of open canopy.

Gypsy moths arrived in the general area of Mt. Marshall in 1982 when male moths were first discovered. Serious tree mortality of chestnut, white, and red oaks, among other species began to occur in 1986. Sustained defoliation and tree mortality continued through 1995. The amount of upper crown canopy losses in the area due to the gypsy moth are 10-85 percent. Gypsy moth impacts were especially bad in the North District due to the coincidence of drought during the late 1980s.

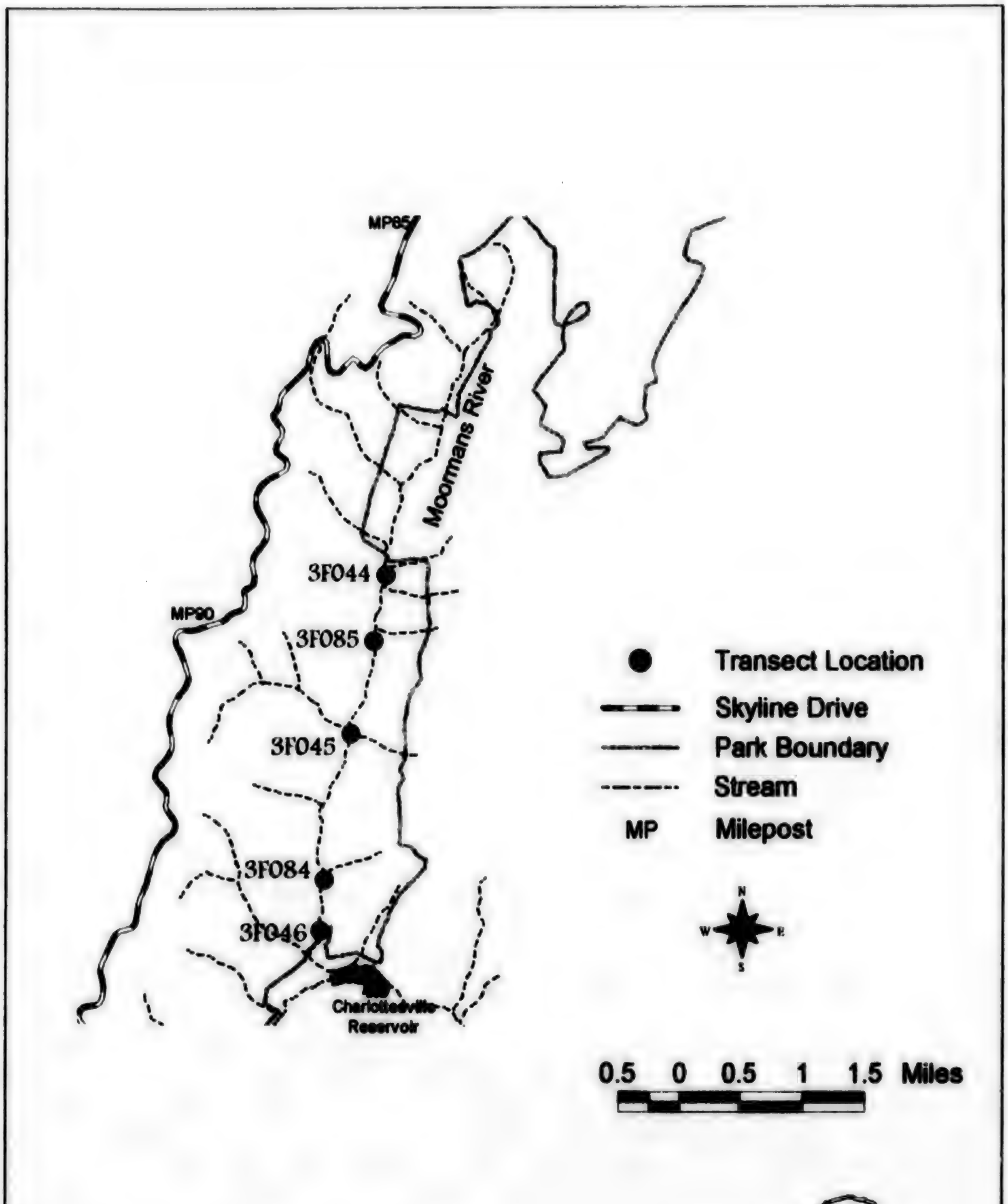

Figure 12. Fish sampling transects located on the North Fork Moormans River, southern section of Shenandoah National Park.

Table 6. Brook trout density, by age class, in North Fork Moormans River, 1983-1995 in five 100-meter fish survey transects. The 1995 data are pre-flood. Transects are listed in order from bottom to the top of the watershed.

Transect Number	Age Class (0-3)	Sample Years													
		1983		1985		1987		1989		1991		1993		1995	
		Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total
46 (Bottom)	Age 0	NS	0.0	0	0.0	0	0.0	18	90.0	23	62.2	18	62.1	3	20.0
	Age 1	NS	0.0	1	100.0	0	0.0	2	10.0	6	16.2	4	13.8	1	6.7
	Age 2	NS	0.0	0	0.0	1	100.0	0	0.0	8	21.6	3	10.3	8	53.3
	Age 3	NS	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	13.8	3	20.0
	Total	0		1		1		20		37		29		15	
84	Age 0	8	53.3	0	0.0	2	40.0	8	53.3	34	63.0	18	37.5	5	27.8
	Age 1	5	33.3	0	0.0	0	0.0	1	6.7	8	14.8	3	6.3	2	11.1
	Age 2	2	13.3	0	0.0	2	40.0	1	6.7	9	16.7	17	35.4	5	27.8
	Age 3	0	0.0	1	100.0	1	20.0	5	33.3	3	5.6	10	20.8	6	33.3
	Total	15		1		5		15		54		48		18	
45	Age 0	NS	0.0	77	77.0	15	23.1	11	20.0	36	36.0	28	28.0	21	25.0
	Age 1	NS	0.0	3	3.0	23	35.4	33	60.0	26	26.0	19	19.0	36	42.9
	Age 2	NS	0.0	16	16.0	26	40.0	7	12.7	34	34.0	45	45.0	20	23.8
	Age 3	NS	0.0	4	4.0	1	1.5	4	7.3	4	4.0	8	8.0	7	8.3
	Total	0		100		65		55		100		100		84	
85	Age 0	9	15.3	180	92.3	35	52.2	21	33.3	75	54.3	36	45.6	5	11.9
	Age 1	29	49.2	2	1.0	16	23.9	31	49.2	42	30.4	9	11.4	24	57.1
	Age 2	20	33.9	12	6.2	16	23.9	10	15.9	20	14.5	28	35.4	13	31.0
	Age 3	1	1.7	1	0.5	0	0.0	1	1.6	1	0.7	6	7.6	0	0.0
	Total	59		195		67		63		138		79		42	
44 (Top)	Age 0	NS	0.0	151	68.6	64	48.5	51	40.5	124	59.0	40	40.8	24	36.4
	Age 1	NS	0.0	22	10.0	29	22.0	63	50.0	59	28.1	9	9.2	24	36.4
	Age 2	NS	0.0	42	19.1	36	27.3	9	7.1	23	11.0	42	42.9	12	18.2
	Age 3	NS	0.0	5	2.3	3	2.3	3	2.4	4	1.9	7	7.1	6	9.1
	Total	0		220		132		126		210		98		66	

	Age Class (0-3)	Sample Years													
		1983		1985		1987		1989		1991		1993		1995	
		Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total	Count	% Total
Stream Summaries by Age Class	Age 0	17	23.0	408	78.9	116	43.0	109	39.1	292	54.2	140	39.5	58	25.8
	Age 1	34	45.9	28	5.4	68	25.2	130	46.6	141	26.2	44	12.4	87	38.7
	Age 2	22	29.7	70	13.5	81	30.0	27	9.7	94	17.4	135	38.1	58	25.8
	Age 3	1	1.4	11	2.1	5	1.9	13	4.7	12	2.2	35	9.9	22	9.8
Total Fish Count for Transect(s)		74		517		270		279		539		354		225	

NS = Not Shocked

Of less importance to the Mt. Marshall area was the impact of hemlock woolly adelgid. The hemlock woolly adelgid was first discovered in the Park in the Thornton River hollow, south of the Mt. Marshall area in 1988. The adelgid and associated hemlock borer activity caused steady decline and mortality of hemlock since that time in Sprucepine Branch and other moist areas.

Infrastructure

The Skyline Drive, built along the crest of the Blue Ridge in SNP, is 105 miles long. The drive was designed and built as an elevated viewing platform for visitors coming to the Park in their automobiles. A large portion Shenandoah's visitors come specifically to experience the scenic vistas from this road. Due to the architectural significance of the drive it is in the process of being nominated for the National Register of Historic Places.

Numerous administrative roads, totalling approximately 100 miles in length, are found throughout the Park. These are unpaved, two-wheel drive roads that are maintained for access to back-country cabins and developed water sources, fire management activities, routes to the Skyline Drive for emergency and administrative purposes, and access to inholders and landlocked parcels of non-Park land. The majority of administrative road mileage is not open to public use, and is generally only minimally maintained.

Shenandoah National Park contains approximately 520 miles of trails, including 95 miles of the Appalachian Trail. The majority of the trails are for hikers, although some are also designated as horse trails.

Due to the long, narrow, and irregular shape of the Park there are approximately 350 miles of boundary which are marked with metal signs and red blazes at regular intervals.

Description of the Event: Hydrological and Geological Processes

During the event, prolonged rainfall resulted in nearly complete saturation of the soils. Intense rainfall at very restricted locations during the morning of June 27 resulted in an excess of 12 inches of rain falling in a period of about two hours (11 a.m. to 1 p.m.). During this period, mass wasting (mostly debris flows) began at numerous locations on the Staunton, Rapidan, and North Fork Moormans river watersheds within the Park and over a wider area outside the Park in the general vicinity of Graves Mill (Madison County).

Continued rainfall during and after the debris flows resulted in profound channeling of the areas affected. Flood discharges far in excess of flows normally experienced likely did not peak until after the mass wasting events, and discharges had sufficient flow competence to remove much of the debris input in the second order streams affected by the storm. The very heavy precipitation combined with an immense short-term influx of sediment and trees from debris flows caused extensive alteration to stream channel systems. Almost all of the non-bedrock channel bottom of the affected streams became mobile during these floods. In addition, new boulders were introduced into the channel systems by the debris flows. Most streamside vegetation in heavily affected areas was uprooted, and channel configurations were substantially altered by these events. In some areas, channels were drastically deepened, widened, and relocated. Bubbling mountain streams, once 15 to 30 feet wide and shaded by streamside trees, were "blown-out," resulting in 150 to 200 foot-wide channels filled with rocks, boulders, and debris dams of de-barked trees. Channel-forming processes were dominated by fluvial action in the upper Rapidan and North Fork Moormans, whereas they were dominated by debris flow action in the Staunton and lower Rapidan. With the exception of localized accumulations in protected locations, most of the sand-sized and finer sediment supplied by the avalanches and channel widening in these headwater channels was carried further downstream, to be deposited along major channels.

In order to provide an indication of the relative magnitude of the event, indirect discharge estimates using the slope-area method were obtained for two sites on the Staunton drainage on August 1, 1995, one site on the North Fork Moormans on August 2, and one site on Big Branch, a tributary to the North Fork Moormans, also on August 2. Channel morphology, water surface slope, and hydraulic roughness data were collected at each site for use in standard hydraulic analyses to estimate peak flood discharges during the event. These estimates have a variable degree of uncertainty attributable to rapidly changing channel geometry, a large portion of the discharge resulting from sediment flux, and the likelihood that the assumed hydraulic parameters of sub-critical, uniform flow were violated at one or more of the cross-sections. Subsequent results of the indirect discharge estimates were then compared to published United States Geological Survey regional flood frequency calculations to establish a recurrence interval.

A comparison of estimated peak discharge values and the calculated 500-year recurrence interval floods is presented in Table 7. The lower Staunton site was judged the best because of a complete bedrock channel and well defined high water marks above and below the cross section. The discharge estimate at this site exceeded the expected regional 500-year value by 28 percent.

Table 7. Comparison of watershed area, estimated peak discharge during the June 27 and 28 flooding, calculated peak of the 500-year recurrence flood, and general quality of both the high water indicator and the cross section suitability for four sites in the Staunton and North Fork Moormans drainages.

Site	Watershed Area (miles^2)	Estimated Peak Discharge (cfs)	500-year Discharge (cfs)	Quality of Estimate
Upper Staunton	1.0	218	1165	Fair
Lower Staunton	2.3	2600	2030	Very Good
N F Moormans	> 16.0	12300	4060	Fair
Big Branch	3.0	6200	2424	Fair to Poor

This measurement is a reasonably good indication that the event was a fairly rare magnitude flood. The only estimate that was below the 500-year value was from the site high in the Staunton watershed, well above any of the severe flooding. It is likely that flood waters had not concentrated at that elevation and therefore a more common discharge of about a 5- to 10-year magnitude was estimated.

The estimates obtained from the North Fork Moormans and Big Branch sites exceeded the expected 500-year value by 200 percent and 155 percent, respectively. The reach of the North Fork Moormans where the measurements were taken had obviously undergone dramatic scouring which very likely created an elevational difference between the channel bed and the high water marks that was more a function of channel evolution than flood magnitude. Big Branch experienced a significant debris flow which very likely increased the stage of the flood wave dramatically, thereby creating an over-estimate.

Calculation of recurrence intervals beyond the 500-year frequency is generally not practiced because of the introduction of time-sampling error. The accuracy of flood frequency estimations based on pure statistical analysis of flow records decreases for probabilities rarer than those defined by the period of record. Therefore, short periods of flow record can not be used to accurately estimate extremely low frequency flood magnitudes (e.g. 1000-year recurrence).

The results of the data analysis, while not providing an unequivocal measure of the magnitude and frequency of the event, strongly suggest that the flood was greater than the expected 500-year magnitude flood based on regional flood frequency equations. Inherent limitations of the data set include the dramatic geomorphic changes that took place on these particular drainages, the small number of indirect measurements, and the error associated with both indirect measurement of extreme discharges and use of purely statistically derived regional flood frequency equations.

The landscape alterations associated with this event were driven by geological processes. Scouring of the slopes revealed a repeated history of debris flow events and suggests that a widespread erosional process in the area occurs during events of major flooding. The condition (or even lack) of surface vegetation due to gypsy moth infestations or other pests had minimal effect on maintaining slope stability relative to the tremendous forces unleashed by the extraordinary amount of moisture associated with this event.

Post-Event Resource Conditions

The debris flows and floods locally exposed deposits from earlier similar events. In places, these deposits contain organic material that could be dated to provide some evidence of flood history of the area. This historical record would be an invaluable tool to refine estimates of flooding potential in the Park. The present flows generally eroded material along their entire track from mountain top to valley bottom, and most sediment was delivered to the channel system. In the few places where material was deposited on lower slopes, it was largely coarse, clastic-supported gravel and boulders. During previous events, much of the material came to rest on the lower mountain slopes, creating fan-like forms with up to 2-6 meters of deposited material.

The effects of this event on groundwater would be extremely difficult to assess. Groundwater flow systems probably were affected in the debris flow areas. The amount of material removed would cause the flow systems to adjust to the new level of the streams. Numerous springs were observed in the affected areas immediately after the event. Many of these springs developed in older colluvial deposits and are near the debris flow areas.

Staunton River

The Staunton River has a small drainage area and a higher gradient compared to the other streams assessed. Flood discharges were therefore likely to be relatively lower, based on the catchment area.

The riverbed is underlain by granitic gneiss without a strong foliation. Granitic gneiss weathers to sand and clay without great shear strength. There is no major structural control by rock type in the drainage. A large number of debris flows (approximately 11) affected both banks (Figure 13). Debris flows contributed a large volume of sand and boulders up to 6 meters in diameter. Flows also entrained a large volume of woody debris. Where the debris flows entered the stream, the flows were mobilized by the stream, thus contributing large quantities of sediment load in the form of both clastic material and woody debris. Compared to the other assessed areas, Staunton River had a much higher amount of debris material and more numerous log jams. Sediment load, in proportion to the amount of flood water, caused the Staunton to behave as a debris torrent. The entire channel and valley bottom were effectively scoured by a series of debris torrents.

Terrestrial Vegetation

Although the middle to lower reaches of the Staunton River were not investigated intensively, a ginseng population in this area was probably removed by the flooding. Impacts are also expected to populations of some species infrequently occurring in the Park, such as umbrella magnolia. In areas where intact live tree roots were present, particularly along the margins of the new channel, some root sprouting of common riparian tree species was occurring. Seedlings of ailanthus and some herbaceous plants were also present in areas where soil was deposited.

The terrestrial LTEM site (2L129) in the middle portion of the Staunton River was investigated and found to have suffered very minimal impacts.

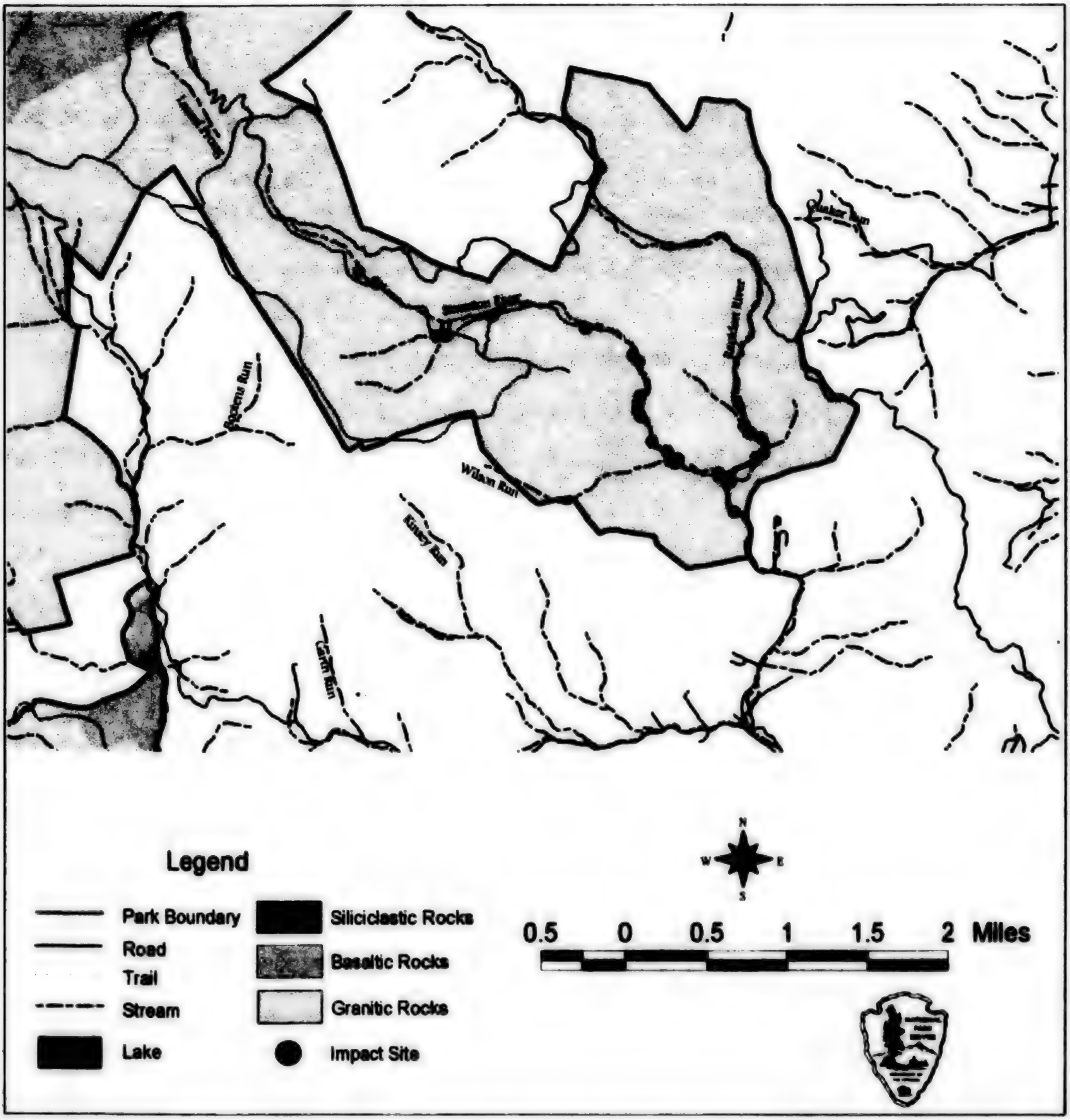

Figure 13. Staunton and Rapidan Rivers with Global Positioning System (GPS) locations of slides inspected during the flood assessment identified.

Stream Morphology

There were a few small debris flows in the upper stream reach, mile point 2.5 to mile point 3.7(the headwaters), but it appeared the stream was only slightly impacted. This stream reach will most likely supply biological stock to the lower reaches.

The middle stream reach, from about mile point 1.4 to mile point 2.5, was moderately impacted. The stream bed was impacted by material and flows from a couple of side channels, including McDaniel Hollow. However, the banks and riparian vegetation, for the most part, remained intact.

From mile point 0.0 (the confluence with the Rapidan) to mile point 1.4, the Staunton River underwent significant morphological changes. In this reach, the stream bed has been significantly lowered and the entire substrate has been replaced. With an estimated 400 foot/mile gradient, this stream had a tremendous amount of power during the flood and there was essentially no floodplain to dissipate the energy. The riffle-pool structure was completely altered; only coarse material (cobble-boulder) remains along with some bedrock to make up the substrate. The finer materials were deposited in the Rapidan River. The stream banks were scoured and the immediate riparian vegetation zones were destroyed.

Streamwater Chemistry

Routine weekly streamwater sampling for alkalinity, pH, and conductivity on the Staunton River, Paine Run, and Piney River was conducted the day before the flooding (June 26) and then after the event on July 7, 11, and 18. Figure 14 provides the weekly alkalinity values for the three streams. In comparison with Staunton River, Paine Run and Piney River were subject to only minor flooding. The lack of any sharp deviation in the Staunton River data suggests that there was no persistent effect on solute concentrations in the weeks immediately following the flooding.

Macroinvertebrates

On July 20, 1995, the SNP aquatics crew hiked through the Staunton River drainage to collect post-event data at the ten sites surveyed in May. Macroinvertebrates were not sampled using standard LTEM quantitative/qualitative methods. Rather, five-minute searches were conducted at each site to roughly standardize the effort in order to describe the magnitude of the impact on the aquatic community.

The organisms were visually sorted and identified to the family level where possible, with attention to the possibility of multiple taxa per family needing separate recognition. Additional observations on the current physical status of the site and obvious abnormalities within the water were recorded. Sample locations are identified in Figure 9.

Two sites were not surveyed; SR13 (Garth Spring Run) was missed and 2F073 could not be located because the area was so drastically changed. In addition, only water data were taken at SR04.

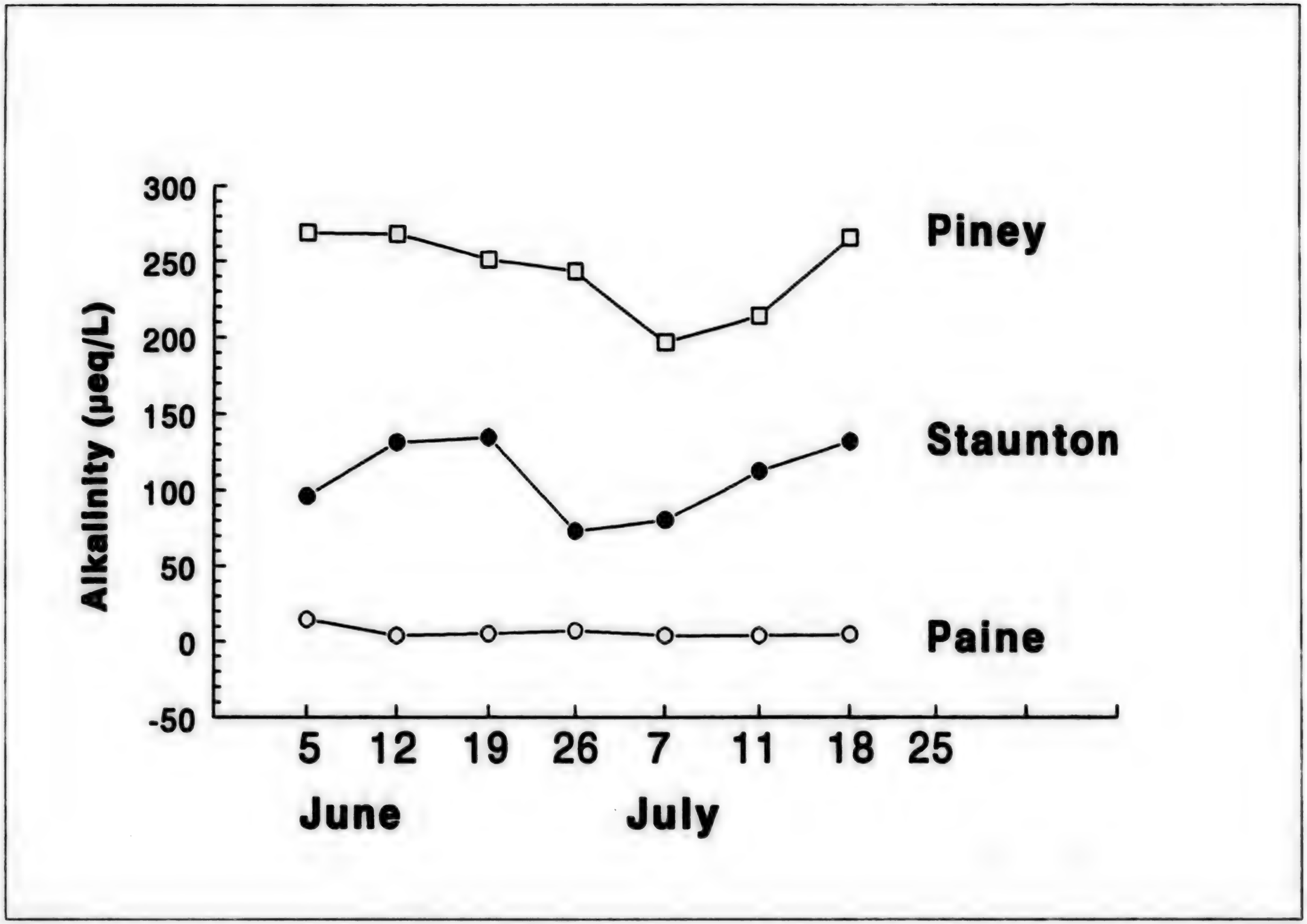

Figure 14. Pre- and post-event alkalinity values for the Piney, Staunton, and Paine Rivers.

The uppermost site in the drainage is LTEM site 2L306, occurring just below a large spring. Evidence of the recent rains was apparent in the combed appearance of streamside forbs. There was very little old leaf debris in the stream. A total of 12 taxa were recorded in the quick survey, including some very young instars (e.g., *Peltoperlidae, Simulium*) which indicated the high probability of a hatch having occurred after the event. Thus, the area had not been so heavily scoured as to destroy or translocate the egg stage for these insects.

The second site (2F076) downstream represented an area where the mainstem had become fully developed. By this point, the event had impacted smaller tributaries--that is, the banks were eroded, streamside vegetation had been removed, and silt sediment covered stream depositional areas. No leaf packs were found in the river, although some sticks and leaves were freshly deposited in riffles. There were 18 taxa recorded from the site, a somewhat reduced number given the stream size and time of year. Very young instars of some taxa were seen.

Site SR11 was located in a subdrainage named McDaniel Hollow. This stream was completely blown out as far up the mountain as could be seen. At the location where the trail paralleling the Staunton River had crossed McDaniel Hollow, the stream was about 2 meters below its former level and 3 meters wide, whereas one "used to hop across it". Fine sediment was visible in all pool areas of the channel. Again, only fresh leaves were in the channel, with all older debris apparently flushed away. Eleven macroinvertebrate taxa were recorded at this site, although finding them proved more difficult than in the upper drainage sites.

Site 2F075 was sampled in the Staunton just upstream from the confluence with McDaniel Hollow. Although clearly visible, the effects of the event in the mainstem were not as dramatic as in the smaller side drainage. The channel was visibly scoured, bed materials were rearranged, and several large trees were down. A few fresh leaves were found in the stream. Some larger boulders appeared to have been rearranged, but the streambanks were mostly intact. The riparian zone was combed but not distinctly altered. At this site, 12 macroinvertebrate taxa were recorded, including early instars. No water striders (*Gerridae*), normally abundant at SNP sites, were found.

At mainstem site SR09, about half-way down the drainage, the true magnitude of the impacts became apparent. Large debris flows were visible on the hillsides. Scouring of the stream bed was clearly evident and the stream banks were moderately eroded, extending the channel width. The stream still was shaded by tree canopy. Fine sediment was abundant and both new and old leaf material was found in the stream. A total of nine macroinvertebrate taxa was recorded, probably not a significant reduction from the last upstream site. Young *Peltoperlids* and *Baetids* were collected. This site yielded two water striders.

At site 2F074, in the mainstream, an approximate 8 acre landslide had occurred on one of the hillsides. Severe scouring had lowered the stream bed one or two meters below its previous elevation. The stream channel was a massive, wide boulder field; there was no longer any tree canopy covering the stream. Noted was the appearance of algal mats in stagnant pools and a slime of semi-transparent, whitish bacterial growth on all sticks and roots in flowing areas. An odor similar to that near sewage treatment plants could be detected. New leaf material was found only in gentle overflows. Only six macroinvertebrate taxa, in very low numbers compared to upstream sites, were found at this site. A general comparison with taxa found upstream indicated that there was a dearth of fast-water, surface-clinging species.

Site 2F073 could not be located, as there were no clear landmarks near the stream or on neighboring hillsides, which contained many debris flows.

LTEM site 2L307 was a standard lower reach Staunton site used for many purposes in several projects. It was unrecognizable, and the former gentle, closed canopy channel was now over 30 meters wide. An amorphous iron oxide precipitate was forming abundantly in leaf-like strands on all stream surfaces except in rapid overflows. Six taxa were found at this site, with three (*Baetid*, *Simuliid*, and *Tipulid*) of those hand-picked off a single large rock with overflow. The only chironomid found was a single "bloodworm." Invertebrates were extremely rare here.

A list of the taxa found at each of the seven sites surveyed on July 20 is given in Table 8. In summary, insects were found at all sites visited, no matter how impacted. There was clearly a difference between the upstream and downstream sites, in both abundance and the number of taxa. Only one site (2F076) yielded any "tortoise-shell" case-making caddisflies (*Glossosma*) that are typically abundant at nearly all stream sites so far examined at SNP. Water striders, which are normally abundant in flotillas consisting of tens or hundreds of individuals, were lacking in most areas despite specific directed searches in the lower reaches. Crayfish were also absent in this cursory survey; they had been present at all sites before the event.

A five-minute visual inspection on August 1 of riffle areas and leaf packs at each of four sites located on a 800 meter stretch of the Staunton River from the confluence with the Rapidan to 100 meters upstream of Wilson Run tributary produced only 2-4 taxa per site. Chironomidae and Simulidae were the dominant taxa at each site and were the only taxa found at the site above the confluence with Wilson Run. A few individuals of the taxa Hydropsychidae and Baetidae were found at three and two, respectively, of the other sites. Chironomidae and Simulidae were significantly less abundant at the site just above the confluence with the Rapidan.

Salamanders

During a single-day visit on August 1, 1995, two (Virginia seal salamander and northern two-lined salamander) of the three previously found species in the mainstem were located in randomly placed m^2 quadrants along the lower mainstem reach of the Staunton River above the SNP boundary. Based solely on the one-day survey results, the abundance of the Virginia seal and northern two-lined salamander was 65 percent and 80 percent, respectively, of pre-flood numbers, even though their habitat was completely rearranged (Table 9). No northern spring salamanders were found during this survey. The seepage area habitat, which had been adjacent to the main channel where the discharge gauge had been located, where the northern dusky salamander was previously found, was completely destroyed.

Table 8. Macroinvertebrate taxa seen in five-minute searches of seven sites on July 20, 1995, within the Staunton River drainage basin. The first and last sites were permanent LTEM sites. Refer to Figure 9 for relative locations of these sites. Asterisks (*) indicate taxa for which a precise family determination could not be made, although they were clearly not the same as others listed.

	Number of Taxa -->	12	18	11	12	9	6	6
Order	Family	2L306	2F076	SR11	2F075	SR09	2F074	2L307
"Platyhelminth"	"Planarian"		X					
Odonata	Gomphidae		X					
Ephemeroptera	Baetidae	X	X	X	X	X	X(2)	X
	Ephemerellidae	X	X					
	Heptageniidae	X	X	X	X	X		
	Leptophlebiidae*		X					X
	Tricorythidae*					X		
Plecoptera	Chloroperlidae	X			X			
	Capniidae/Leuctridae		X	X				
	Peltoperlidae	X	X	X	X	X	X	
	Perlidae*		X	X	X			
	Perlodidae		X					X
	Pteronarcyiidae	X	X	X	X	X	X	
Trichoptera	Glossosomatidae		X					
	Hydropsychidae	X	X	X	X	X		
	Limnephilidae*				X			
	Philopotamidae	X		X	X		X	
	Rhyacophilidae		X					
Hemiptera	Gerridae					X		
Coleoptera	Elmidae	X	X	X	X			
Diptera	Chironomidae	X	X	X		X		X
	Simuliidae	X	X	X	X	X	X	X
	Tipulidae	X	X		X			X

Table 9. Staunton River salamander densities pre- and post-event. Preliminary analysis of density data (total number of adult and juvenile salamanders per m^2) for mainstem transects only. Pre-event and post-event data were obtained in May 1995 and August 1995, respectively.

Species	Pre-event	Post-event
Virginia seal salamander	0.35/m^2	0.23/m^2
Northern two-lined salamander	0.05/m^2	0.04/m^2
Northern spring salamander	0.09/m^2	0.00/m^2
Number of meter-square quadrants	100	67

Fish

SNP fish survey transect 072, just above the confluence with the Rapidan, was sampled on July 13, 1995 and no fish of any species were detected. In seven previous years, this section has yielded as many as five fish species and an annual average count of 83 brook trout (Table 10). Transects 073 and 074, also in the lower stream reach, were not sampled due to personnel safety concerns. In 1993, these two sections yielded three fish species each and the average annual brook trout counts of transects 073 and 074 from 1983 to 1993 were 100 and 90, respectively. Transects 075 and 076 in the upper and middle stream reaches were sampled on July 24, 1995 with comparable, albeit somewhat depressed, results with previous years. Fish populations in these two sections suffered few if any apparent affects from the event.

Rapidan River

The resource assessment of the Rapidan River drainage was to include only the area upstream from the confluence with the Staunton River. From visual observations of the area immediately upstream from the confluence, it was apparent that there were significantly less impacts to that portion of the Rapidan drainage compared to the Staunton River. Therefore, efforts to assess the post-event resource conditions of the Rapidan were limited.

Terrestrial Vegetation

A large assemblage of rare species located in the upper reaches of the Rapidan River was investigated and the plant communities were found to be intact; the significant flood impacts began much further downstream. Vegetation impacts were investigated just upstream from the confluence with the Staunton. Several small debris flows and one large debris flow on the west side of the Rapidan had tree root sprouts occurring along the edges of the flows. Some

Table 10. Pre- and post-event brook trout densities and fish species diversity from five 100-meter transects in Staunton River.

Transect Number	Pre-flood Brook Trout Count Average 1983-1993	Post-flood Brook Trout Count 1995	Fish Species Present in 1993	Fish Species Post-flood 1995
72	83	0	AME, BKT, BND, TRS	No Fish
73	100	Not Shocked	AME, BKT, BND	Not Shocked
74	90*	Not Shocked	AME, BKT, BND	Not Shocked
75	102*	63	BKT	BKT
76	93	54	BKT	BKT

* Transects 74 and 75 were not shocked in 1984, therefore the averages represent six sample years rather than seven.

AME = American Eel
BKT = Brook Trout
BND = Blacknose Dace
TRS = Torrent Sucker

herbaceous seedlings and ailanthus seedlings were coming up in areas where soil was deposited. Along the main channel of the Rapidan where banks were cut back root sprouts of several species, most notably spicebush, were present. Bark was removed from numerous trees still standing in cobble/pebble bars located in and along the channel. Several umbrella magnolias along the channel were dying due to bard removal. Entire trees and tree trunks were also found lying in and along the channel.

Stream Morphology

Above the confluence with the Staunton, the river has an estimated gradient of 80 to 100 feet/mile, considerably less than the Staunton River. This gradient, along with a wide flood plain, helped dissipate the energy of water. The stream bed substrate and riffle-pool structure was mostly left intact as were the banks and riparian vegetation. Most debris flows that were examined did not reach the stream channel, therefore sediment input was greatly reduced. However, considerable amounts of soil, sand, and gravel were still deposited in the floodplain. Changes in channel configuration appear to be dominantly fluvial in character in contrast to the Staunton River.

Streamwater Chemistry

No data are available.

Macroinvertebrates

On August 1, five-minute visual inspections of riffle areas and leaf packs at each of four stream sites within a 400 meters upstream stretch of the river beginning at the confluence with the Staunton found a diverse macroinvertebrate assemblage. Between 6 and 11 taxa were identified at the sites, with the least number found at the site just above the confluence with the Staunton. Baetid mayflies dominated the three upstream sites; many were ready to emerge, mate, and lay eggs, as indicated by dark wing pads. In addition to the four taxa found in the Staunton, individuals of the taxa Brachycentridae, Glossomatiidae, Philopotamidae, Oligoneuriidae, Heptageneiidae, Peltoperlodae, and Perlidae were identified. Brachycentridae and Philopotamidae were only found at one site, about 15 meters upstream of the confluence with the Staunton.

Salamanders

No salamander surveys were conducted.

Fish

Transects 136, 091, and 092 were sampled on July 26, 1995. Only the uppermost transect (136) produced comparable brook trout numbers with previous years (Table 11). Brook trout were found in transects 091 and 092 but in significantly less numbers than in previous years. Transects 135 and 134 were not surveyed due to limited access and safety concerns.

Although below the confluence with the Staunton, transect 093, at the Park boundary, was sampled on July 13, 1995. Only 19 individual fish representing three species were recorded. No brook trout were found. This transect has produced as many as nine fish species and an average annual count of 32 brook trout in previous years.

North Fork Moormans River

The approximate 4-mile section of the North Fork Moormans River within the Park below Tobacco House Hollow was assessed. Slides and slumps were abundant. Well developed debris flows were not as prominent as in the Staunton drainage mainly because the elevation of the inception of many of the failures was closer to the stream. Slides had just developed into debris flows at the stream intersection. Most mass failure occurred on the dip slope on the west side of the stream. Material in the debris was smaller than that in the Staunton drainage, ranging from clay-rich soils to small boulders (Figure 15).

Fine red clay coated the rocks within the North Fork Moormans River channel. Flood discharge in the Moormans appeared to be of a much higher magnitude than in the Staunton, but debris input was much less. Morphological changes in the stream valley were dominated by fluvial processes. Sediment load transported by the flood discharge resulted in extensive deposition of

Table 11. Pre- and post-event brook trout densities and fish species diversity from six 100-meter transects in Rapidan River.

Transect Number	Pre-flood Brook Trout Count Average 1983-1993	Post-flood Brook Trout Count 1995	Fish Species Present in 1993	Fish Species Post-flood 1995
93	32	0	AME, BKT, BND, CMS, LND, MOT, RVC, RSD, TSD, TRS	BND, LND, RSD
134	57	Not Shocked	AME, BKT, BND, BLC, LND, MOT, MRD, RVC, RSD, TSD, TRS	Not Shocked
92	85	16	AME, BKT, BND, LND, TRS	AME, BKT, BND, LND
135	82	Not Shocked	AME, BKT, BND, LND, TSD	Not Shocked
91	84	31	AME, BKT, BND, LND, TSD	AME, BKT, BND, LND
136	108*	101	BKT	BKT

* Represents averages from 1985 - 1993

AME = American Eel
BKT = Brook Trout
BND = Blacknose Dace
CMS = Common Shiner
LND = Longnose Dace
MOT = Mottled Sculpin
MRD = Mountain Redbelly Dace
RVC = River Chub
RSD = Rosyside Dace
TSD = Tessellated Darter
TRS = Torrent Sucker

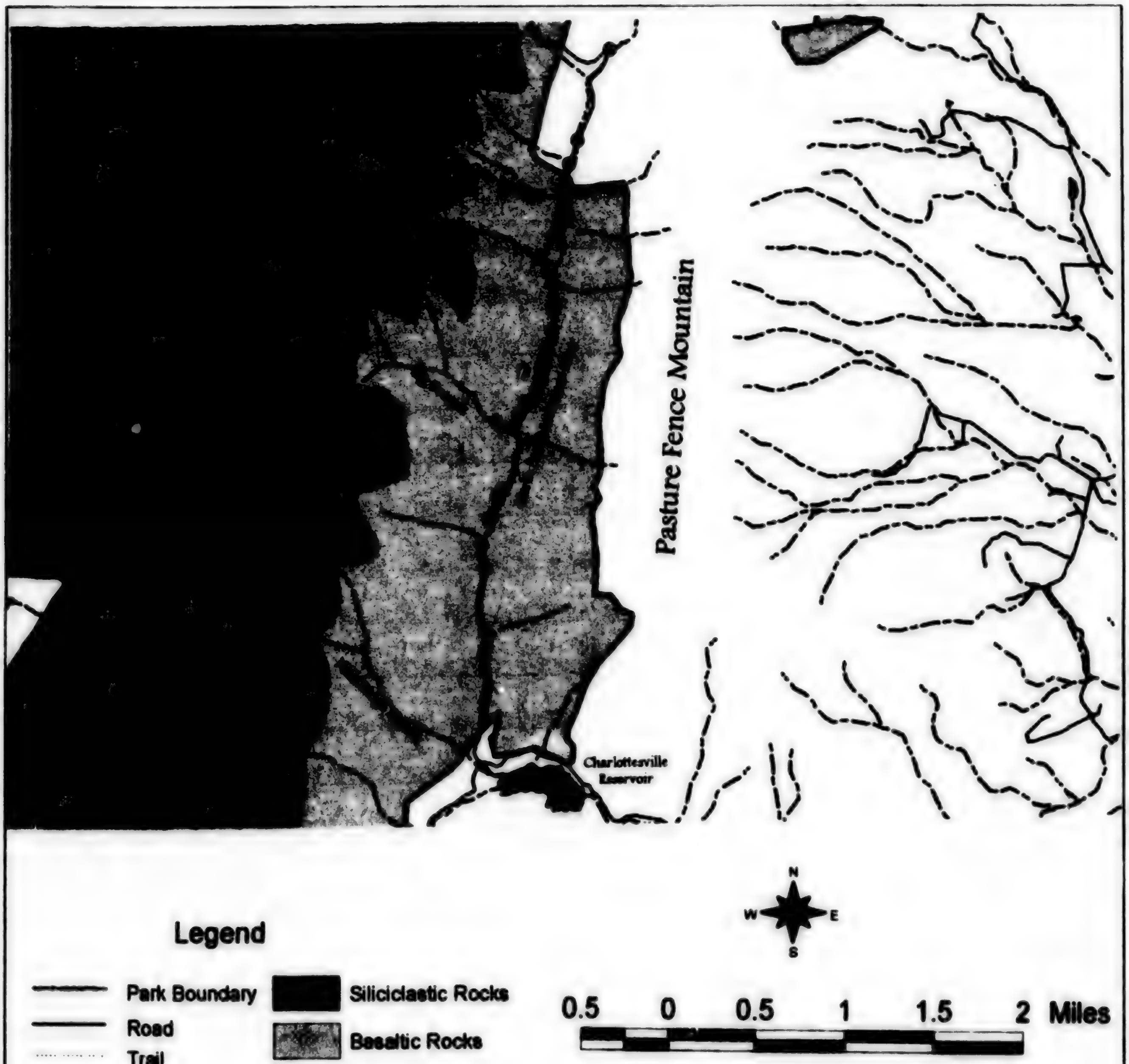

Figure 15. North Fork Moormans River with Global Positioning System (GPS) locations of slides found during the flood assessment identified.

clastic material and woody debris in the Charlottesville Reservoir, which acted as a catchment basin for sediment and significantly reduced further downstream damage from the event. If pre-event bathymetry and/or pre-dam topography is available, an estimate can be made of sediment input to the reservoir. Sediment storage within the channel and immediate floodplain of the North Fork Moormans was much greater than in the Staunton.

Terrestrial Vegetation

A few populations of plant species that are infrequently found in the Park, but not uncommon enough to be listed as rare by the Virginia Natural Heritage Program (VNHP), were affected by the event. The riparian vegetation zones were significantly impacted, especially along the lower reach. Populations of ginseng and white monkshood (*Aconitum reclinatum*) along the North Fork Moormans River were washed away. Both species are on the VNHP Watchlist. A turtlehead (*Chelone glabra*) population along Big Branch was also removed. Only bare rock now exists along Big Branch between the waterfall and the stream's confluence with the North Fork Moormans River. Prior to the flood, this area was tree covered and contained lush riparian vegetation.

The terrestrial LTEM site (3L118) in a hemlock forest cover type is located in a landslide area along the North Fork Moormans River. All three plots at this site received significant damage. Twenty-two meters of one (24 x 24 meters) side of one plot disappeared into the river. Another plot was almost completely covered in varying depths by a debris flow. Surprisingly, only nine of the previous 103 trees present in the three plots were lost. LTEM site 3L110 was not investigated. Although it is not believed to be in an impacted area because of the surrounding topography, it was established very close to the river and may have suffered some impact due to the erosion of the riverbank.

Stream Morphology

The lower two miles of this river in the Park were significantly altered by the flood. The substrate in the stream bed has essentially been entirely reworked and replaced by the flood. The bulk of the material is cobble, with some boulders present. The stream gradient in this reach is about 200 feet per mile; less than the Staunton, but still capable of generating enough power to move large particles. The banks in this reach were severely damaged. In some areas the banks were eroded to a depth of about 20 feet.

Streamwater Chemistry

No data are available.

Macroinvertebrates

Like the Staunton drainage, the North Fork Moormans was impacted heavily in some areas. On August 2, 1995, quick surveys for aquatic macroinvertebrates were conducted at five sites: the upper and lower Park boundaries, the Shop Run and Big Branch tributaries, and just above Big Branch's confluence with the mainstem. The results of these quick surveys are given in Table 12.

The number of aquatic invertebrate taxa observed was fairly good (10-19 taxa) throughout the drainage, with significant bacterial mats seen primarily in the lowermost reach of the mainstem.

It is noteworthy that water striders were present throughout the drainage and that crayfish were seen; this is in contrast to the apparent negative effects on these taxa in the Staunton drainage. And, although the kinds of invertebrates present during the survey appeared sufficiently diverse, there was a definite lack of stoneflies in and below Big Branch. The usually abundant stoneflies are leaf shredders and predators, and make up significant amounts of fish food at certain times of the year.

Since there are no pre-event data for comparison, it will be impossible to estimate the impact. It does appear that prior to the event the stream had both abundant kinds of numbers of aquatic invertebrates.

Salamanders

No salamander surveys were conducted.

Fish

SNP fish survey transect 084 was intensively sampled with three-pass removal depletions prior to the event on June 15, 1995. A total of 824 fish representing 13 species were recorded. The sample included 30 brook trout and 2 brown trout. This same transect was resampled in the same manner on July 10 (post-event), resulting in the capture of only 6 individual fish representing 4 species (Table 13). Only 1 brook trout, an age 3 fish, was present.

Mt. Marshall Area

The debris flows in this area originated near the volcanics/granitics boundary and became well-developed downslope. The depositional zone of the debris flows are just outside the western Park boundary. There is no conclusive evidence that suggests that surface flow associated with culvert outlets caused the debris flows; however, there probably is an indirect linkage. Any reconfiguration of culvert locations will likely not decrease debris flow potential in future similar events. Standard management practices have been used in road drainage design in this area (mileposts 15 to 18) of the Skyline Drive.

The area during the event described by some local residents as "Amber Falls" was in fact not a new natural feature. Locations of remaining moss on the face of a large granite rock, vegetative root remains, and topographical features at the site indicate a pre-existing waterfall situation. The area is fed by several small seeps and it is apparent that water typically "weeps" off of this granite face, with surface water runoff and perhaps a small waterfall occurring during exceptional rainfall events. Prior to the recent storm, this site was not visible from the valley below because it was hidden by heavy tree canopy which has been removed for at least 60 feet in width by the debris slide high up on the ridge. The feature is probably not even "seasonal" since a waterfall was non-existent just four weeks after the event.

Table 12. Macroinvertebrate taxa seen in five-minute searches of each of five sites on August 2, 1995, within the North Fork Moormans River drainage basin. There were no previous LTEM macroinvertebrate sites in this system for comparative data. Refer to text for relative locations of these sites. Asterisks (*) indicate taxa for which a precise family determination could not be made, although they were clearly not the same as others listed. Numbers in parentheses indicate totals found.

	Number of Taxa -->	10	12	19	11	14
Order	**Family**	**1st Slide**	**Shop Run**	**Geol CX**	**Big Branch**	**Boundary**
Decapoda	Cambaridae (Crayfish)	X	X		X	
Ephemeroptera	Baetidae	X		X	X	X(2)
	Ephemerellidae*			X		X
	Heptageniidae				X	
	Oligoneuridae*			X		
Plecoptera	Peltoperlidae		X	X		
	Perlidae*		X	X		
	Pteronarcyidae		X	X		
Trichoptera	Glossosomatidae	X	X	X		X
	Hydropsychidae	X	X	X	X	X
	Limnephilidae*	X				
	Philopotamidae	X	X	X	X	X
	Polycentropodidae*			X		
	Rhyacophilidae		X	X	X	X
Hemiptera	Gerridae	X	X	X	X	X
Coleoptera	Elmidae			X		
	Dryopidae*			X	X	
	Ptilodactylidae	X				
Diptera	Blepharoceridae			X		
	Ceratopogonidae			X		X
	Chironomidae		X	X	X	X(2)
	Simuliidae	X	X	X	X	X
	Tipulidae	X	X	X	X	X(2)

Table 13. Pre- and post-event fish species densities from transect 084 in the North Fork Moormans River.

Species	Pre-flood Count Data June 15, 1995	Post-flood Count Data July 10, 1995
Blacknose Dace	205	2
Bluehead Chub	6	0
Brook Trout	30	1
Brown Trout	2	0
Common Shiner	1	0
Fallfish	39	0
Fantail Darter	67	0
Johnny Darter	2	0
Longnose Dace	8	0
Margined Madtom	23	0
Mountain Redbelly Dace	61	0
Northern Hogsucker	175	2
Rosyside Dace	205	1
Totals:	824	6

The watersheds which contribute to this area are relatively small and mostly within the Catoctin volcanics group which has well developed foliation. These volcanics weather to red clay with very little quartz in the weathered zone and prominent saprolite. The area is extremely steep with loose rock and gravelly soil and, therefore, the area is very difficult and somewhat hazardous to hike. Although some minor natural sliding of soil and rock will continue to occur, no additional major sliding (even with heavy rains) should occur due to the severe scouring that has already occurred in the drainage. Additional debris slide threat to neighboring lands and to people is unlikely.

Infrastructure

An assessment of the trails and administrative roads was completed on July 27. The trail assessment was coordinated by each of the three SNP district resource management specialists. Assessment of the Skyline Drive was completed during the first week of August by the SNP Professional and Technical Services personnel and Federal Highway Administration employees.

Skyline Drive

A trail crew in the Skyline Drive milepost 15 (milepost numbers increase north to south with milepost 0 being the start of the Skyline Drive at the Park's northern boundary) area during a particularly intensive rainfall on Tuesday, July 27 at about 0745 hours reported approximately 8 inches of water rushing down the drive and a landslide, at mile 14.7, obstructing the drive. The historic Skyline Drive suffered slope failures, drainage ditch erosion, undermining of culvert headwalls, and culvert outfall erosion from mileposts 1 to 19. The greatest damage was localized in the area between mileposts 14 and 19, the area between Hogwallow Flat Overlook and Mount Marshall Overlook.

Repairs are needed to protect the historic Skyline Drive from additional damage from normally expected rainfall. The Federal Highway Administration assigned a team of hydrologists and highway engineers to develop a scope of work and a cost estimates for these needed repairs. This team estimated that the repairs will cost approximately $40,000 - 50,000.

Administrative Roads and Trails

Results of the road and trail assessments confirmed that the most severe flooding was very localized in the North Fork Moormans River, Staunton River, Rapidan River, Pocosin Hollow, Mount Marshall, and Conway River drainages. A summary of the flood effects in each Park district follows. For specific information regarding trail and administrative road conditions see Appendix C (Trails/Backcountry Road Data and Repair Cost Estimates).

North District: The North District is delineated as all Park lands north of Route 211. The district contains 142 miles of trails and 16 miles of administrative roads. One of the Park's two visitor centers is located in the district. Although virtually all administrative roads and trails received some degree of erosion due to the heavy rains, most damage was considered minor and could be handled as routine maintenance. Lands Run and Gravel Springs roads had some heavily washed out areas, but were fixed with minimal efforts.

The most severe damage to North District trails occurred in the area between Hogwallow Flat Overlook and Mt. Marshall Overlook, Skyline Drive mileposts 14 to 19. Severe flash flooding occurred on both sides of the mountain, in the Mount Marshall and Browntown areas. Large sections of the Mount Marshall and Bluff trails were heavily washed out and the Appalachian Trail in the North Marshall area was severely eroded.

The most dramatic terrain changes, erosion, and trail damage in the district occurred between Waterfall Branch on Mount Marshall trail and the Big Devils Stairs trail junction with the Bluff trail.

Central District: The Central District is the largest district and is delineated as Park lands between Route 211 and Route 33. The district contains two concession-run lodges, one of the two Park visitor centers, and a large campground. There are 241 miles of trails and 57 miles of administrative roads.

The trail assessments showed that the most severe flood effects occurred in the Rapidan River, Staunton River, Conway River, and Pocosin Hollow drainages. Trails were affected by rock and mud slides and surface water flow. Trails were severely eroded and rocks, boulders, and downed trees were found in the trail corridors and along stream crossings. In many lower sections, there was widespread root exposure and tree bark scouring which will likely cause some future tree mortality.

The two most affected trails in the Central District were the Staunton River Trail and the Pocosin Hollow Trail. Many sections of the Staunton River Trail (or access road) were completely missing and large amounts of trail material were washed into the Staunton River. Other sections of the trail were so deeply rutted (3-5 feet) that they are down to boulder and bedrock and well beyond repair. Many small side drainages were completely blown out due to debris flows and high waters. The trail contained numerous debris flows, woody debris piles, rocks, and boulders. The bottom 1.5 miles of the Staunton River Trail does not appear restorable and presents potential safety hazards.

The 1.5 mile lower section of the Pocosin Hollow Trail was impacted similar to the lower Staunton, except that the Pocosin trail had more sections of intact trail. Many sections of the trail have become small stream beds, major debris flows are found throughout, and large boulders, rocks, and debris are blocking many sections of the trail.

Other trails such as Lower Nicholson Hollow, Jones Mountain, McDaniel Hollow, Saddle, Cedar Run, the Appalachian Trail near Dean Mountain, and Pocosin Horse received moderate damage along all or some of their length. Trail rehabilitation appears possible on all of these trails.

Trails such as White Oak Canyon, Ridge, Hannah Run, Rose River Loop, Buck Ridge and Buck Hollow received minimal damage and can be repaired.

South District: The South District is delineated as Park lands between Route 33 and Interstate 64 and is the southernmost section of the Park. The Blue Ridge Parkway joins the Skyline Drive at its southern terminus. The area contains 139 miles of trails and 26 miles of administrative roads.

Although heavy rains fell throughout the district, the heaviest were mostly localized in the North Fork of the Moormans drainage. Most of the district's trails had minimal to moderate impacts related to heavy water flow. Doyles River, Jones Run, Paine Run, and Riprap trails were affected by washing and sediment flow. Waterbars were filled, some tread was lost, some large trees fell across the trails, and culverts were affected.

The administrative road that follows the North Fork Moormans River sustained the greatest damage related to the flood. Approximately 15 large debris flows and high waters affected the roadbed. The assessment indicated that six areas totalling approximately 1400 ft will need to be rerouted and 22 areas totalling approximately 3300 ft need to be critically evaluated as to whether reconstruction is feasible. To open the road, regrading, possible rebuilding with support structures, and rerouting will be necessary in 16 distinct areas.

Park Boundary

Some sections of Park boundary, especially along stream channels and steep slopes, will need to be re-surveyed, monumented, and marked to replace monuments and markings that were destroyed by landslides and major stream channel changes. The Park's backcountry staff has not yet been able to check all boundary areas, but has so far identified 5 miles of boundary survey work that is needed to support resource protection. At an estimated cost of $5,000 per mile, total costs for boundary survey work will be $25,000.

Summary

The assessment determined that a total of 37 miles of Park roads and trails were affected by the event, mostly in six distinct drainages which include the North Fork Moormans River, Staunton River, Rapidan River, Pocosin Hollow, Mt. Marshall and Conway River. The nature and extent of the damage was related to the intensity of rainfall and subsequent debris flows in isolated areas. Total cost estimates associated with the repair or replacement of damaged roads, trails, and boundaries is approximately $337,000. The cost breakdown by category is summarized in Table 14.

Table 14. Summary of infrastructure repair costs.

Infrastructure Component	Estimated Repair Cost
Skyline Drive	$50,000
Administrative Roads and Trails	$242,000
Boundary Re-survey	$25,000
Total	**$317,000**

Predicted Recovery Processes and Management Concerns

General Geomorphology

Over a period of decades to hundreds of years, the channel systems of the Staunton, Rapidan, and North Fork Moormans rivers will gradually evolve back towards their pre-flood equilibrium conditions. These changes will occur on different time scales, and the rate of change will be dependent on the magnitude of discharges in subsequent years. Regrowth of riparian vegetation will occur rapidly with resprouting and new seedling establishment occurring within the next 1-5 years and complete coverage of areas with available soil may take 10-30 years. A similar recovery will occur on portions of debris flow tracks not scoured to bedrock. The probability of additional minor mudflows and slumps will be reduced as vegetation recovers. Exposed bedrock slopes will remain relatively bare for hundreds of years.

Continued fine-grained sediment input to all drainages is to be expected; in the North Fork Moormans this input will have a higher proportion of clay in contrast to the Staunton and Rapidan rivers. Over the short term (3-5 years), the exposed regolith along debris flow tracks will erode readily during normal rainfall events. Much of the sand and silt will be deposited in the valley bottoms, helping to reconstruct floodplain soils and gradually narrow the channels towards their pre-flood width. In addition, sand and fine gravel from the exposed debris flows will be deposited in pools and eddies along the main channels. Summer thunderstorms will continue to move moderate-sized boulders for several years until a more stable arrangement is created and pools and riffles are reestablished.

The large volume of instream sediment stored in the North Fork Moormans will continuously be reworked during moderate flows. This will generate a persistent sediment input to the Charlottesville Reservoir that will be greater than it was during pre-flood conditions.

Staunton River

Terrestrial Vegetation

In the middle and lower sections of the Staunton River, the large width of the new channel and amount of coarse material and exposed bedrock will retard the process of tree establishment and growth in the riparian zone. The development of tree canopy coverage of the stream may take decades. Although some sprouting was noticed, most of the woody species that will colonize the debris flow and riparian areas will likely be of seed origin. Unfortunately, *Ailanthus* seedlings were the most common species noted. Herbaceous plants were already regenerating in these areas and will respond quickly where adequate soil exists.

Stream Morphology

Changes will occur slowly in the lower stream reach. Normal high flows (bank-full every 1-2 years) will increase the amount of smaller materials in the substrate composition and may raise the stream bed. Unstable banks will be reshaped over time into a stable configuration and revegetation will occur.

Recovery in the middle stream reach should be relatively quick. The impacts to McDaniel Hollow will take longer to recover and this stream will input some bedload to the mainstem.

Streamwater Chemistry

Although examination of the weekly composition data obtained for Staunton River during the first three weeks after the event suggests that no immediate response occurred, there are theoretical reasons for predicting that important changes may eventually be observed. Two opposing hypotheses are suggested with respect to flood-related changes in streamwater chemistry. One is that the intensity of acidification may increase; the other is that the ANC or acid-neutralizing capacity of the system may increase.

One of the more dramatic changes that occurred on this stream was the removal or radical alteration of the riparian deposits. This may result in an alteration of episodic or storm-flow chemistry. Through processes of solution and precipitation, the riparian zone provides buffering of acidity associated with high-flow conditions. This may be important in a system such as Staunton River, where relatively minor episodic acidification was previously documented. The observation of heavy flocculent on the stream bed of Staunton River following the event suggests that processes or conditions controlling the mobility of iron and aluminum in the riparian zone have been altered. The movement of these elements suggests that the buffering capacity of the riparian zone may be diminished, possibly on a long-term basis.

The second hypothesis for change in streamwater chemistry involves the potential for accelerated weathering of rock and soil material disturbed by the debris flows and scouring. With fresh surfaces exposed, the release of weathering products such as silica and base cations should increase. Although the largest proportion of the watershed area was not actually disturbed during the event, much of the disturbance did occur in areas associated with primary hydrologic flow paths. The disturbed areas will have a disproportionate amount of contact with water moving through the watershed. The most probable effect of increased weathering in the watershed would be increased generation of base cations. This may tend to increase the ANC of the system.

Macroinvertebrates

Macroinvertebrates have already begun to reinhabit the lower stream reach. Insect eggs were observed in the stream. The recovery of the macroinvertebrate community will proceed naturally and without any needed intervention or assistance. Colonization of denuded areas will take place by downstream drift of larvae and nymphs from the less impacted headwater areas, and also by fly-in of adult insects from nearby areas. At least in the short term, the post-event macroinvertebrate community may be structurally different than the pre-event community because of increased sunlight and stream temperatures from canopy removal in the riparian zone. Primary production may rapidly increase and those taxa that are adapted to feeding on algae (e.g. Baetidae) may move into the impacted reach relatively quickly. Studies have shown these insects to respond rapidly to canopy removal by logging. Shredder insects may respond less quickly because of the reduction in the amount of leaves, an important autumn food source, falling into the river. Potential changes in riparian vegetation species composition may alter the type and amount of leaf litter being deposited in the lower section of the stream, thereby potentially altering the composition of insect species dependent on leaf inputs.

Any structural modification in the invertebrate community will be to capitalize on these changes, and eventually the system will reach a new equilibrium state reflecting the current character of the stream ecosystem.

Salamanders

Natural flood events alter streamside salamander communities in two ways, elimination of some species and reduction of the population sizes of others. The event did not eliminate the salamander community. Population sizes of the two most common species were reduced only 20-40 percent of pre-flood sizes based on the limited samples. Although one species may be extirpated, additional surveys are necessary for confirmation. It is likely that the streamside salamander community will eventually recover in the Staunton River. It remains to be seen, however, how long it takes for the populations to reach pre-flood levels and whether species presumably eliminated will recolonize the river. Intervention in the natural recovery process would not appear to offer any advantage over natural recovery.

Fish

Fish have already migrated into the lower reaches, possibly from the Rapidan River. Warm water fish species, such as stonerollers, may be the first to colonize. The predicted rapid increase of insects will provide a food base. A change in the streamwater temperature regime due to the lack of canopy shading may impede the return of a permanent trout fishery for years. Recolonization rates and permanence of fish species will be influenced by the development of quality instream fish habitat and subsurface spring flows that may offer refuge areas during low flow periods during warm summer months. Water quality responses will play a major role in determining the rate of recovery.

Rapidan River

Terrestrial Vegetation

The area above the confluence with the Staunton River sustained less flood related changes in the channel than found downstream. Although there are some areas where the tree overstory was completely removed and the channel was widened significantly, the tree canopies along this section of stream will fill in quickly over the next two or three years. Areas along the stream banks where bare tree roots are exposed or are near the soil surface will revegetate quickly by sprouting. Many new sprouts from species adapted to the riparian areas have already begun to appear since the event. Much of the forest floor in the riparian area was severely flooded and fine sediments from uphill debris flows have moved downhill. Herbaceous plants have already responded and the affected areas will revegetate quickly. In the open areas of the larger debris flows, much of the regeneration will be from seed origin. Although several species of woody plants were noted, the most common seedlings were *Ailanthus*. The presence of *Ailanthus* seedlings is a result of seed trees being present in the nearby woods and stored seeds in the forest floor.

The area along the Rapidan River downstream from the confluence with the Staunton River was severely scoured by the high waters and debris flows. Vegetative recovery, particularly for woody species, will take many years due to the large amount of bedrock exposed, the course nature of the rock material deposited, and the large width of the channel. The only area of immediate concern is just inside the Park boundary along the first debris flow coming down to the road where, a large patch of kudzu (*Pueraria lobata*) appeared to have been present prior to the event. New kudzu runners are already growing into the debris flow area. The increased light and lack of competition in the disturbed area will encourage the widespread growth of this exotic invasive plant.

Stream Morphology

Above the confluence with the Staunton, where impacts were localized and less extreme, recovery should occur relatively quickly, similar to the middle reach of the Staunton. Changes will occur much more slowly below the confluence where higher waters and debris flows severely scoured and widened the stream channel.

Streamwater Chemistry

The predictions or hypothesized changes in streamwater chemistry described for Staunton River are applicable to the Rapidan.

Macroinvertebrates

The recovery scenario for macroinvertebrates will likely be similar to the Staunton and will proceed naturally and without any needed intervention or assistance. Colonization may occur more rapidly because the impacts were not as great, as demonstrated by the greater post-event number of taxa in the Rapidan River. Large populations of Baetidae, a grazing insect, were found on August 1 just upstream of the confluence with the Staunton. Studies have shown these insects to respond rapidly to canopy removal. Shredder insects will likely respond much later as the amount of leaves, an important autumn food source, falling into the river increases.

Salamanders

No pre-event and post-event data are available for predicting recovery. However, based on surveys of the Staunton River, it would appear that any impacts to salamander populations will be eventually remedied.

Fish

As with the Staunton, warm water fish species, such as stonerollers, may be the first to recover in the impacted lower reach of the Rapidan. The predicted rapid increase of insects will provide a food base. A change in the streamwater temperature regime due to the lack of canopy shading may impede the return of a permanent trout fishery. Water quality responses will play a major role in determining the rate of recovery.

North Fork Moormans River

Terrestrial Vegetation

The small slips and debris flows found in the North Fork Moormans River drainage will quickly revegetate with woody and herbaceous plant species. Some small slips carried the plants downhill intact like a large carpet moving across the ground. In areas where root material was still present, sprouting has already occurred. Seedlings also already appeared, growing from seeds present in the soil or blown in from adjacent areas. Revegetation of the large debris flows and main channel below the major slides will respond in a manner similar to the Staunton River area. The wide channel area and newly exposed soil areas within the debris flows will be vegetated primarily by seed. Diversity will be dependent upon seed source availability. Many *Ailanthus* seedlings were present in both small and large openings, mainly due to the presence of large seed trees. Tree canopy development in the most impacted sections of the main stream and Big Branch channels will be a slow process that may take decades.

Stream Morphology

This system may be quite unstable for some time. There are numerous slide areas with great potential for movement. Considerable bank sloughing and changes in substrate composition will occur before the stream reaches an equilibrium.

Streamwater Chemistry

The predictions or hypothesized changes in streamwater chemistry described for Staunton River are applicable except for turbidity levels which will remain higher than pre-flood conditions, particularly during storm events, due to the higher percentage of clay present in the Moorman's watershed.

Macroinvertebrates

As with the Staunton, the North Fork Moormans macroinvertebrate community will adjust naturally to the event-related impacts. This adjustment will likely be easier and quicker since this system appeared less impacted. Recovery processes will include recolonization efforts by insects from above and below the impact areas, and a possible adjustment in community structure and specific diversity to capitalize on the current food type availability.

Salamanders

No pre-event and post-event data are available for predicting recovery. However, based on surveys of the Staunton River, it would appear that any impacts to salamander populations will be eventually remedied.

Fish

Several species of fish were observed in the stream. The stream channel was severely scoured during the flood, but macroinvertebrate recruitment was already in progress. As with the Staunton River, the increased potential for photosynthesis and a change in the temperature regime may alter the development of both the benthic and fish community structures from that of pre-event conditions.

Mid-day water temperatures at the three previous fords in the North Fork Moormans River were 23°C on August 2, which is very marginal for brook trout. Some fish species may be dependent on the deeper pools and subsurface spring flows to provide some temperature relief. Higher water temperatures during low flow conditions may also reduce dissolved oxygen levels, thereby influencing fish species survivability. Park visitors are now using some of these deep pools for wading and swimming. This activity will likely cause a severe stress to the few remaining fish in the lower section of the river.

Mt. Marshall Area

Some rockfall and minor debris flow activity can be expected in the North District debris flow areas over the short term (1-5 years). Discharge from culverts will likely inhibit the filling of hollows by colluvial activity.

Recommendations

Agencies or individuals identified in parentheses and italics at the end of a specific recommendation are those initially identified as suggested leads for implementing the recommendation.

Immediate Actions

Mitigate Safety Hazards

These flood/debris flow events need to be understood in the context of geological processes. They are extreme events and therefore it is highly likely that the high flood hazard zone has been defined in the heavily affected areas; avoidance of any development in these areas would provide a high degree of flood safety.

Although a debris flow event in the Appalachian region can be expected to occur every 15-20 years, extreme events within a given drainage area appear to have a much lower probability. The likelihood of further extreme events in the same areas is reduced, although secondary mud flows and/or rock falls can be expected. Debris flow channels or chutes, as well as deposits of flows, slides, or slumps, should be considered unstable and therefore they constitute a degree of hazard. Some continued slumps, landslides, and rockfalls can be expected until slopes become stabilized with woody vegetative cover.

Extremely steep unconsolidated slopes are unstable and are difficult to walk upon. Undercut stream banks adjacent to trails and administrative roads constitute significant hazards.

Although some significant safety hazards do exist, it is not necessary to close areas to use if the Park can provide adequate explanation to visitors who enter the areas of the hazards and how to minimize risk. Therefore, it is recommended that the Park:

- Restrict or discourage use of former trail or road areas with undercut stream banks or near "toe" areas at the base of the most unstable debris flows, especially along the Staunton River. If use is allowed, mark alternative routes away from these areas either more towards the middle of the floodplain or higher on the slope for the undercut banks, or on the opposite side of the drainage for the debris flow sites. *(SNP - Districts)*

- Develop methods for explaining hazards to visitors to these areas through signing or pamphlets. In particular, visitors must be advised to avoid areas of debris flows during or immediately after rains. *(SNP - Districts and Interpretation & Education[I&E])*

- Take no mitigation action in the Mt. Marshall slide area. The potential natural hazards (loose tread and rocky slopes) are obvious. The initial novelty of the slide, which is quite clearly visible from the Browntown area at the base of the mountain, appears to be lessening for local adventurers/hikers. Access to the site is difficult and is best from the Skyline Drive.

Two additional issues of concern include the potential for fire danger associated with log jams and future movement or landslides of the trapped unstable material. The log jams and other organic debris within the Park that were assessed do not pose a significant hazard to burst or catastrophically move downslope. Most of the debris appears to be locked tightly in piles left behind by the high flood waters. However, there is ample "pore" space in the piles and they are not likely to impound a significant quantity of water. If the dams did not wash downstream during the catastrophic event in June 1995, then they are not likely to break apart during future normal rain events. Logs stuck in the jams are more likely to rot than burn. Fires are carried by small fuels, not large logs, and most debris piles are isolated by unvegetated slide areas rather than in the middle of forests. No manipulation of log jams or debris piles is recommended.

U. S. Geological Survey (USGS) is formally inventorying all hazards, including the organic debris. An initial report was provided to the Federal Emergency Management Agency (FEMA) in late October 1995. The USGS inventory will be more comprehensive than this assessment, which was limited to three watersheds. Initial feedback indicates that their findings are consistent with what was determined through this assessment.

Protect Vulnerable Resources

Biologically, there is no reason to close the streams to fishing if the current catch and release regulations are maintained. Therefore, the temporary stream fishing closures which had been issued should be lifted. *(SNP - Superintendent)*

The Park will work with the state to prevent the stocking of any fish in the Rapidan and North Fork Moormans drainages outside the Park where they may affect native brook trout populations within the Park. It is recommended that fish not be stocked in the Park to supplement natural recovery or to provide temporary "put and take" fisheries. *(SNP - Center for Resources[CfR])*

Kudzu noted in the Staunton drainage should be eliminated before it colonizes the disturbed areas. There is likely no realistic control for the *Ailanthus altissima* which is colonizing disturbed areas in all drainages. *(SNP - Central District and CfR)*

Public Information

A *Site Bulletin* or other similar handout on the 1995 floods should be prepared prior to the 1996 spring visitor season. It should briefly describe:

- What happened and what Park facilities were impacted
- Current closures or other visitor use restrictions
- Frank discussion of safety issues
- Advice on how to safely visit the areas that remain open and what is likely to happen over time both to the natural systems and infrastructure (roads, trails, etc.). *(SNP - I&E, CfR, and Districts)*

SNP and the Virginia Department of Game and Inland Fisheries(VDGIF) should develop a joint media release explaining the status of fishing on the affected streams, both in terms of access (closures and logistics) and safety, and quality of fishing to be expected. In general, anglers should be advised that fishing is going to be poor (except for upper Rapidan) and walking conditions are unstable. *(SNP CfR; and VDGIF)*

The current status of areas is:

Staunton: From confluence to 1.5 miles upstream, walking is hazardous due to large boulders. At the bottom of debris flows adjacent to the stream there is a lot of loose rock and other material. Recommend warning visitors of hazardous conditions.

Rapidan: No real hiking access problems. There is no vehicle access between the lower Rapidan and upper Rapidan Wildlife Management Area due to road damage just below the confluence of the Staunton and to the Rapidan Road coming from Criglersville.

North Fork Moormans: Stream bed and road are unstable. In general, areas in this drainage are more dangerous than the Staunton because of the geological substate. If warnings are developed for the Staunton, similar ones should also be developed for the North Fork Moormans.

Near-Term (prior to summer 1996)

Infrastructure Repair/Rehabilitation

○ Do not build or rebuild any trails or administrative roads in affected drainages until after winter 1995-96 to allow for some settling and continued slumping and rockfalls. *(High priority - Districts and Professional and Technical Services [P&TS])*

○ Repair the Skyline Drive damage. *(High priority - Districts and P&TS)*

○ No stabilization of debris slopes is recommended at this time. Slides will continue to erode with rain events and some rocks will move, but massive failures are not expected under normal meteorological conditions. Rapid natural revegetation should help to stabilize loose soils within a few years. Artificial vegetative seeding or planting would not likely speed the process. *(High priority - Districts and P&TS)*

Documentation/Proposal Development

○ Document flood assessment and scientific inventory, monitoring, and research proposals in SNP Resource Management Plan. *(High priority - CfR)*

○ Publish this report in an appropriate NPS scientific report series, and distribute widely. *(Medium priority - CfR)*

○ Document flood affects and assessment process in *Park Science*. *(Medium priority - SNP CfR)*

Establish New Baselines

- Reinstall water chemistry samplers and stream stage recorder on the Staunton and continue with streamwater sampling program at least at pre-event levels. *(High priority -SNP CfR; and University of Virginia [UVA])*

- Inventory all landslide areas; develop digital maps; and prepare detailed geologic assessment. *(High priority - USGS under FEMA grant)*

- Initiate quantitative geomorphology studies including identifying and describing all unstable banks, debris pile stability, and surveying crown scars of debris flows to determine the likelihood of recurrence or reactivation. *(High priority - USGS as part of FEMA project and/or NPS/USGS cooperative research project. NPS Water Resources Division [WRD] and/or Geologic Resources Division [GRD] technical assistance will be requested for site-specific analysis, if needed.)*

- Repeat basinwide macroinvertebrate survey of Staunton River to match pre-flood data taken spring 1995. Evaluate these data to determine necessity for continuation of periodic surveys as part of SNP long-term ecological monitoring (LTEM) program. *(High priority - SNP CfR)*

- Monitor SNP fish survey transects on the Staunton, Rapidan, and North Fork Moormans rivers on an annual basis until further notice. *(High priority - SNP CfR)*

- Survey stream profiles to characterize the immediate post-flood environment on Staunton and Moormans. Establish a small number of long-term monitoring cross sections and photo points to document changes in channel width, sediment, and vegetation, as well as other channel characteristics. Determine appropriate sampling interval for integration into existing SNP LTEM program. *(Medium priority - SNP CfR and P&TS; and NPS WRD)*

- Systematically examine the debris channels and avalanche tracks within the Park to document older debris flow deposits and to obtain, where possible, buried organic materials that could be dated. Such a systematic documentation needs to be conducted quickly, since continuing slumping and erosion (particularly due to winter frosts and rain) and vegetation regrowth will soon obscure these exposures. *(Medium priority - USGS)*

- Establish groundwater level and spring discharge monitoring networks. *(Low priority - NPS WRD)*

Interpretation and Education

- Recommend high priority interpretive strategies from those outlined in the following Interpretative section and implement them. *(SNP I&E and Districts)*

Outreach

- Provide user, special interest, and community groups with interpretive and educational materials to educate them and cooperate with them to seek support for appropriate responses to flood-related issues and potential rehabilitation efforts *(High priority - all SNP units)*

- Get involved with planning for the Charlottesville reservoir to explain Park position and carefully evaluate any proposed actions. *(High priority - SNP South District and CfR)*

- Work cooperatively with VDGIF to solidify and document mutual understandings and committments to shared objectives between agency staff on fisheries management and regulatory issues. Revising the existing Memorandum of Understanding (MOU) may be appropriate. *(Medium priority - SNP CfR and Resource and Visitor Protection Services [R&VPS]; and VDGIF)*

- Develop a close linkage with National Weather Service (NWS) personnel for implementing a warning system. An emergency management system needs to be developed, including a hierarchy and decision tree for rapid response actions *(Medium priority - SNP R&VPS)*

- As more weather data are acquired from NWS, USGS, and local sources, rainfall amount charts will be updated. (Not all data will be normalized and some data will be from non-standard collection methods and observations.) Prepare a map of the Park and surrounding areas with rainfall amounts during the event at each data collection point. *(Medium priority - SNP CfR)*

Long-Term

Monitoring

- Fisheries: Develop and implement a fisheries monitoring sampling strategy to measure fish community recovery as part of restructured SNP-VDGIF cooperative monitoring efforts. *(Can be covered under existing funding levels)*

- Basinwide Habitat Surveys: Re-do basinwide habitat survey on Staunton River comparable to those recently completed. Initiate annual basinwide survey on North Fork Moormans on same scale as Staunton to gather information on recovery processes. Determine re-sampling interval based on need and available funding. *(Will require additional funding)*

- Vegetation Recovery: Develop and implement a simple vegetation monitoring strategy (e.g., transects or photo points) for the Staunton and North Fork Moormans rivers and the Mt. Marshall slide to document and monitor natural ecological changes in the long term. (Can be covered under existing funding levels)

Research

The following list of potential research issues was provided by the participants in the flood assesment; there are undoubtedly many more. The list is not in priority order. Before setting specific flood-related research priorities, SNP will review ongoing and prior scientific studies, evaluate the flood assessment information, and determine Park management issues. Decisions by the Park to request NPS or outside funding sources to initiate any research project will be based on the potential value of the information to the Park for making management decisions or providing a better understanding of Park resources. Unsolicited requests (not directly supported by NPS funds) to conduct research in the Park will be evaluated on technical merit, compatibility with Park objectives and NPS policy, and level of necessary Park committments.

Effects of the elimination of the riparian forest and the restructuring of the hyporheic zone on baseflow and episodic hydrology and chemistry.

Recovery rates of the mobilities of cations and anions.

Changes in the pool and riffle structure and woody debris loading.

Changes in the thermal regime.

Changes in allochthonous inputs.

Recolonization of macroinvertebrate and fish communities.

Fish diets and utilization of existing food base.

Structural (in)stability of stream channel.

Effects on secondary productivity.

Effects of the new source areas for large woody debris on instream processes.

The half-life and stability of "recently" added large woody debris.

The importance of autochthonous/allochthonous inputs to the energy-budget.

The location and quality of spawning habitats.

Impacts of algal/fungal/bacterial organisms on the biotic community.

Movements of aquatic and aerial stages of insects into and out of the impacted areas.

Dating of previous mass wasting events through C^{14} or other chronological indicators.

Geomorphic changes of the stream channels.

Probabilistic risk assessment for mass wasting and floods for the entire Park.

Sedimentological study of Charlottesville Reservoir.

Evaluate role of roads and other infrastructures on slope stability.

Systematic surficial studies of the Rapidan drainage basin.

Storm flow routing in the North District area in relation to road drainage.

Recovery comparisons between the Staunton and Moormans rivers.

Vegetative recovery in the affected stream channels and adjacent riparian zone.

Infrastructure Repair/Rehabilitation

The initiation of repair/rehab/closure of trails will be dependent on available money. Since no additional appropriations are available, areas will be repaired only where it can be done with existing resources. Except in a few cases where roads or trails are considered absolutely essential, trail and road repair will not be initiated until spring 1996. For some roads and trails, the extent of the damage may prohibit repair and will require permanent closure and possibly some level of stabilization.

Major reroutes of trails or roads in not recommended, although it is noted that due to the structure of the underlying bedrock, trails on the east side of Moormans River will be safer than on the opposite bank.

Interpretative and Educational Opportunities

Interpretive Implications

The events of June, 1995, provide dramatic opportunities to illustrate the on-going process of change in the natural communities of the Blue Ridge Mountains. This is very similar to a fire, which opens the forest canopy to allow people to witness the regeneration process following that natural event. The floods and landslides have bared the earth temporarily, uncovering the early geological formations and the beginnings of the Blue Ridge story. The regeneration and the changes that will follow provide the Park with an excellent opportunity to understand and interpret the interactions of the various processes and communities that occur on a regular basis.

The North Fork Moormans, Rapidan, and Staunton rivers provide unique resources for hands-on exploration and interpretation of intense, but natural, events. The wealth of baseline data and the future collection of data on the recovery of the different biological systems will be an interpretive and educational tool for both specialized and regular interpretive offerings.

Audience

The most difficult and challenging obstacle is the remoteness of the most obvious impacted locations. This limits the ability for on-site interpretation to traditional Park visitors. However, the compelling story of the event can be incorporated into existing programs through interpretive techniques and media. Target audiences can be matched with appropriate interpretive techniques. Target audiences are:

- Park visitors
- Local communities directly affected by flooding
- Key user groups (hikers, Potomac Appalachian Trail Club [PATC], fish groups, horse riders, campers)
- Education groups - most likely in Albemarle, Greene, and Madison counties
- Special interest groups (potential adult seminar candidates, Friends group, college or continuing education classes)
- Park interpretive staff

Strategies for Reaching Different Audiences

Strategy 1 - Integrate the event into current interpretive programming

The flood and debris flow events fit well into current Park interpretive themes. By providing interpreters with background data, assessment reports, and continuing data on the systems' recovery, as well as appropriate interpretive props, they will be able to incorporate the event into current interpretive programs. Actions include:

- provide a training session for Park interpretive staff which could potentially include a hike of one of the drainages
- centralize information generated from the assessment and create files for slides, written documents, maps, color prints so that information is available to interpreters
- assemble a small workgroup to investigate the development and need for interpretive props, such as Geographic Information System (GIS) products, periodic photography of selected areas, and video edit and scripting.

Strategy 2 - Develop pilot adult seminar

The remoteness of the affected areas makes hands-on interpretation of the event difficult. In the context of an adult seminar, groups can be taken to these places to see first hand what has happened. This format would be appropriate for an all-day program. Actions include:

- set date for program and collect information concerning the event
- coordinate with different agencies/professionals/rangers to lead the program
- advertise program in media of counties adversely impacted by event
- choose program site and hike route in one of the drainages

Strategy 3 - Create interpretive media

The existing photography, video footage, and GIS products can be evaluated for use in developing general or specific interpretation programs for Park visitors and user groups as well as props for incorporation into existing Park interpretive themes. User group liaisons may combine or amend information as necessary. Actions include:

- provide visual and written information to user group liaisons as quickly as possible
- work with unit interpreters to identify needs, techniques, and suggested media
- prepare listing of available materials

Strategy 4 - Offer programming for education groups

Accessing the impacted areas from the boundary may prove beneficial in dealing with local school groups. The Park receives many requests each year for "geology" programs. These areas (especially the Moormans) provide great opportunities for school field trips with regards to travel time. Actions include:

- contact local educators at the high school and junior high levels to develop this type of program
- research area that could be used for programs (keeping in mind safety and geologic interest)
- create "resource" packet for teachers to use in conjunction with local issues or curriculum

Appendix A

Definitions of Key Terms

Blowout - small saucer, or cup-shaped depression in soil and weathered rock caused by liquification and the complete removal of the previously contained material in a small debris flow.

Catoctin volcanics - sequence of volcanic flows and ash falls that outcrop in the central Appalachian mountains from central Virginia north to southern Pennsylvania and which are especially prominent in Shenandoah National Park.

Colluvium - a general term applying to loose and incoherent deposits of soil, weathered rock, and rock usually at the foot of a slope brought there chiefly by gravity.

Debris Flow - a form of rapid mass movement of granular solids, water, and vegetation with flow properties that vary with water content sediment size, and sorting of particles. Debris flows can have inception as a minor soil slip or landslide forcing soil and rock out over downslope material overpressuring the water in saturated soil and rock. The result is to liquify the down slope material, a loss of coherency, and degeneration of mass movement into rapid flowage.

Granitic gneiss - general term for rocks rich in quartz and feldspar minerals which have been altered by heat and pressure and have compositional layers alternating between darker and lighter colored minerals.

Hollow - area above head of streams which fill with colluvium, weathered rock (saprolite), or soil. Over time, these areas become less stable and are susceptible to ground failure during periods of high soil moisture.

Saprolite - weathered rock which has not been transported and which retains the structures and morphology of the parent rock.

Slides - earth movement involveing shear displacement along one or several surfaces or within a relatively narrow zone.

> Rotational - movement of earth material along a surface of rupture that is concave upward resulting in a rock or earth slump.
>
> Translational - movement of earth material along more or less planar or gently undulatory surfaces. Frequently controlled by surfaces of weakness such as faults, joints, or bedding planes resulting a land slide, rock slide, or debris slide.

Strike/Dip - means of orienting planar features on a map. Strike is the intersection of an inclined plane with a horizontal plane (the map surface). Dip is the angle of inclination of the plane, measured from the horizontal and perpendicular to the strike.

Appendix B

Contributors

The following individuals have assisted in the preparation of this report. We apologize for any omissions.

Name	Primary Contribution	Agency (Affiliation)
Jim Atkinson	Fisheries	Shenandoah National Park, NPS
Steve Bair	Roads/Trails (ND)	Shenandoah National Park, NPS
Michelle Batcheller	Editing	Chesapeake/Allegheny System Support Offices, NPS
Tom Blount	Operations Section Chief; biological resources; editing	Shenandoah National Park, NPS
Art Bulger	Fisheries	Dept. of Environmental Sciences, University of Virginia
Bill Cook	Air operations; interagency liaison	Shenandoah National Park, NPS
Patricia B.W. Deitrich	Field assessments; logistical support	Shenandoah National Park, NPS
David Demarest	Field assessments; logistical support	Shenandoah National Park, NPS
Frank Deviney	Fisheries	Dept. of Environmental Sciences, University of Virginia
Andy Dolloff	Fisheries	U.S. Forest Service, Virginia Tech
Mark Duffy	GPS	Assateague Island National Seashore, NPS
Heath Edelman	Field assessments; logistical support	Shenandoah National Park, NPS
Sharon Emerson	Logistical support	Shenandoah National Park, NPS
Keith Eshelman	Hydrology	Dept. of Environmental Sciences, University of Virginia

Name	Primary Contribution	Agency (Affiliation)
Bob Gochenour	Surveying	Shenandoah National Park, NPS
Jim Green	Biological Resources	U.S. Environmental Protection Agency
Shawn Green	Initial Reconnaissance; roads/trails	Shenandoah National Park, NPS
Rolf Gubler	Initial Reconnaissance; roads/trails	Shenandoah National Park, NPS
Kelly Hartsell	Interpretive Strategy	Shenandoah National Park, NPS
Don Hayes	Hydrology	Water Resources Division, U.S. Geological Survey, Richmond VA
Janice Henline	Typist	Kelly Temporary Services
Alan Howard	Geomorphology	Dept. of Environmental Sciences, University of Virginia
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John Karish	Scientific Assessment Team Leader; biological resources; editing	Chesapeake/Allegheny System Support Offices, NPS
John Kinde	Air operations; initial reconnaissance	Shenandoah National Park, NPS
Kim Koenig	Field assessments; logistical support	Shenandoah National Park, NPS
Bob Krumenaker	Incident Commander; geomorphology; editing	Shenandoah National Park, NPS
Kevin Leftwich	Fisheries	U.S. Forest Service, Virginia Tech
Shawn Lehman	Field assessments; logistical support	Shenandoah National Park, NPS

Name	Primary Contribution	Agency (Affiliation)
Mike Martin	Hyrology/ geomorphology	Water Resources Division, NPS
Karen Michaud	Interpretive Strategy	Shenandoah National Park, NPS
Joseph C. Mitchell	Amphibians (Salamanders)	Department of Biology University of Richmond (Funded by DoD Legacy 2000 Program)
Henry Molina	Field assessments; logistical support	Shenandoah National Park, NPS
Ben Morgan	Geomorphology	Geologic Division, U.S. Geological Survey, Reston VA
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Charlie Newton	Roads	Shenandoah National Park, NPS
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Tracy O'Connell	Editing, typing	Penn State University
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Sheri Shawver	Editing; typing	Penn State University
Claire Smith	Field assessments; logistical support	Shenandoah National Park, NPS
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Name	Primary Contribution	Agency (Affiliation)
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Shane Spitzer	Meteorology; data support	Shenandoah National Park, NPS
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Greg Stiles	Planning Section Chief	Shenandoah National Park, NPS
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Jim Swift	Field assessments; logistical support	Shenandoah National Park, NPS
Steve Tessler	Macroinvertebrates; data support	Shenandoah National Park, NPS
Julie Thomas	Information Officer	Shenandoah National Park, NPS
Reese Voshell	Macroinvertebrates	Dept. of Entomology, Virginia Tech
Rick Webb	Watershed chemistry	Dept. of Environmental Sciences, University of Virginia
Randy Winstead	Botanical resources	Shenandoah National Park, NPS

Appendix C

Trail/Backcountry Road Data and Repair Cost Estimates

NORTH DISTRICT

ROADS/TRAILS

ASSESSMENT

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Appalachian Trail Mile 14 to 16	
Location/District	North	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	White	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	2	
Estimated Staff Days (required for rehab)	80	
Cost Estimate	$17,000.00	COMMENTS: Some rehab work already completed by PATC; most work can be accomplished by volunteer PATC crews.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Bluff Trail	
Location/District	North	
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	2	
Estimated Staff Days (required for rehab)	300	
Cost Estimate	$34,600.00	COMMENTS: Trail is "unrepairable" with major tread scouring throughout 2 miles of trail from Spruce Pine to Big Devils Stairs drainage.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

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RESOURCE ASSESSMENT OF THE JUNE 27
AND 28,1995 FLOODS AND DEBRIS FLOWS
IN SHENANDOAH NATIONAL PARK... U.S.
DEPT. OF THE INTERIOR... APRIL 1997

2 OF 2
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SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Gravel Spring Hut Road	
Location/District	North	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	1.5	
Estimated Staff Days (required for rehab)	40	
Cost Estimate	$1,600.00	**COMMENTS:** Rehab work can be completed by routine maintenance operation.
Priority Level (Low/Mod/Hi) (for trail rehab)		
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Harris Hollow Trail	
Location/District	North	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	80	
Cost Estimate	$13,000.00	**COMMENTS**: Assessment refers only to 1.0 mile section of trail within park boundary. Last remaining good boundary access to Big Devils Stairs.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Jenkins Gap Trail	
Location/District	North	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	0.8	
Estimated Staff Days (required for rehab)	240	
Cost Estimate	$16,500.00	COMMENTS: Trail is "unrepairable" with 36" tread loss throughout for 0.8 miles; would require relocation/project clearance.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Jordan River Trail	
Location/District	North	
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	1.0	
Estimated Staff Days (required for rehab)	60	
Cost Estimate	$12,500.00	COMMENTS: Entire 1.0 mile length of trail needs rehab work.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Lands Run Road	
Location/District	North	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	.08	
Estimated Staff Days (required for rehab)	40	
Cost Estimate	$1,600.00	**COMMENTS:** Rehab work is nearly complete as of 7/26/95.
Priority Level (Low/Mod/Hi) (for trail rehab)		
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level:1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Mt. Marshall Trail	
Location/District	North	
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	.5	
Estimated Staff Days (required for rehab)	300	
Cost Estimate	$34,000.00	COMMENTS: Trail is "unrepairable" with major tread scouring in about .5 miles of trail area.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations		

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

CENTRAL DISTRICT

ROADS/TRAILS

ASSESSMENT

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	**Description of Damage**
Trail Name	Berry Hollow Fire Road	**Washed out areas in the lower sections, plugged ditches and culvert ends.**
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	3	
Estimated Staff Days (required for rehab)	30	
Cost Estimate	$8,500.00 ($4,000 gravel)	**COMMENTS:** Need to pull ditches, dig out culvert pipes and grade. Need 20 loads of mix.
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations	Maintain to pre-flood level.	

Damage Level:1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Big Meadows Nature Trail	* Minor erosion on small sections of the trail.
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Nature Trail	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0.05	
Estimated Staff Days (required for rehab)	1	
Cost Estimate	$110.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Fill is small sections of trail where tread has washed out.	TOTAL TRAIL LENGTH: 1.1 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Buck Hollow	* Minor erosion throughout trail
Location/District	Central	* Several large blowdowns ranging from 15" - 30" in diameter.
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.2	
Estimated Staff Days (required for rehab)	16	
Cost Estimate	$1,980.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Add checkdams/waterbars, sidehilling, cribbing	TOTAL TRAIL LENGTH: 3.0 miles

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	**Description of Damage**
Trail Name	Camp Hoover to Fort Mountain	
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1.5 miles	
Estimated Staff Days (required for rehab)	10	
Cost Estimate	$5,000.00 for gravel	COMMENTS: Need to replace culvert pipes 350 feet. Haul mix material (10 loads).
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Maintain to pre-flood level.	

Damage Level:1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Cedar Run Trail	• Minor erosion on small sections of trail.
Location/District	Central	• Waterbars need to be cleaned.
Wilderness (Yes/No)	Yes	• Large blowdown (24" diameter).
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0.1	
Estimated Staff Days (required for rehab)	3	
Cost Estimate	$550.00	COMMENTS: 6 hazardous trees 0.5 miles down 12" - 16" in diameter.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Add checkdams/waterbars, sidehilling and cribbing.	TOTAL TRAIL LENGTH: 3.1 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Conway River Fire Road	Need to pull ditches, clean culverts, haul about 10 loads of material for washouts.
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	.5	
Estimated Staff Days (required for rehab)	10	
Cost Estimate	$3,500.00 ($2,000.00 gravel)	**COMMENTS:**
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	Yes (possible opening Va)	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations	Maintain to pre-flood level.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Graves Mill, Lower Rapidan	This is the most heavily damaged road in the park. It will take extensive rerouting and reconstruction on the lower end if it is to be put back to pre-flood level.
Location/District	Central	* NEPA/106 compliance would be required.
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	2	
Estimated Staff Days (required for rehab)	160	
Cost Estimate	$66,000.00	COMMENTS: Blakey Ridge Road still allows access for visitors into the Rapidan area & Wildlife Management area.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	yes	
Trail Sections Obliterated?	Yes	
Potential Hazards to Hikers	Yes	
Recommendations	Leave this road closed indefinitely (see comments)	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Jones Mountain Trail	• Approximately 250 feet of erosion.
Location/District	Central	• Three (3) large blowdowns ranging from 30" - 40" in diameter.
Wilderness (Yes/No)	No	• Waterbars need cleaning.
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.1	
Estimated Staff Days (required for rehab)	10	
Cost Estimate	$1,050.00	**COMMENTS:** Hazard leaner approximately 3.4 miles down from Cat Knob (20" diameter).
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Trail needs sidehilling, cribbing and checkdams.	**TOTAL TRAIL LENGTH:** 5.5 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Laurel Prong	• 15 feet of minor erosion.
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0.1	
Estimated Staff Days (required for rehab)	0.6	
Cost Estimate	$70.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Install two (2) checkdams	TOTAL TRAIL LENGTH: 2.3 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Lower Staunton River Trail	• The stream now runs where the trail use to be in many sections.
Location/District	Central	• Unstable sections of trail.
Wilderness (Yes/No)	No	• Numerous landslides and debris piles.
Use Level (Low/Mod/Hi)	Moderate	• Potential for subsequent/additional damage to trail sections by future storms.
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	1.5	
Estimated Staff Days (required for rehab)	80	
Cost Estimate	$14,000.00	**COMMENTS:** Presently the area is closed to fishing, hiking and overnight camping. For the purposes of this assessment, this trail was split into two parts. The total length of the Staunton River Trail before the flood was 3.9 miles.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	Yes	
Trail Sections Obliterated?	Yes	
Potential Hazards to Hikers	Yes	
Recommendations	Trail needs to be completely re-routed. Recommend indefinite closure below intersection of Jones Mountain	**TOTAL TRAIL LENGTH:** 1.5 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	McDaniel Hollow	* Large number of rocks deposited on trail.
Location/District	Central	* 20' of severe trail erosion (3' deep gullies).
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Low	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.1	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$2,100.00	**COMMENTS:** Possible PATC summer crew project.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Use present rock to build cribbing; sidehill west side and use for fill. Add checkdams/ waterbars.	**TOTAL TRAIL LENGTH:** 0.4 mile.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Mill Prong Horse Trail	Major erosion gullies 2' deep for .1 mile.
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	.1 mile	
Estimated Staff Days (required for rehab)	3	
Cost Estimate	$650.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Add waterbars and checkdams.	TOTAL TRAIL LENGTH: 1.2 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	**Description of Damage**
Trail Name	Nicholson Hollow Trail	* Very little erosion.
Location/District	Central	
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0	
Estimated Staff Days (required for rehab)	5	
Cost Estimate	$650.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Clean waterbars and redistribute tread material.	TOTAL TRAIL LENGTH: 5.5 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Old Rag Road	Need to pull ditches, clean culverts, and put material back on road (15 loads).
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$7,000.00 ($4,000 for mix)	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Maintain to pre-flood level.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Pocosin Fire Road	
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$9,000.00 ($6,000 gravel)	COMMENTS: Moderate damage to lower gate, needs to be graded and dirt hauled.
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	Yes (currently)	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations	Maintain to pre-flood level.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Pocosin Hollow Trail	• Major wash out areas throughout trail.
Location/District	Central	• Many sections of trail have become small streambeds.
Wilderness (Yes/No)	No	• Major rock/mudslides throughout.
Use Level (Low/Mod/Hi)	Moderate	• Large boulders and debris blocking many sections of trail, (very hazardous to hikers).
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1.5	
Estimated Staff Days (required for rehab)	70	
Cost Estimate	$12,000.00	**COMMENTS:** Recommend that this trail stay closed until further assessments can be made. If may be possible to open upper half if deemed necessary. However, most use on this trail is for fishing access from the boundary.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	Yes	
Trail Sections Obliterated?	Yes	
Potential Hazards to Hikers	Yes	
Recommendations	Presently this trail is closed to hiking/BC camping.	**TOTAL TRAIL LENGTH:** 2.6 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Pocosin Hollow Horse Trail	• Minor erosion throughout entire trail.
Location/District	Central	• Waterbars are washed out.
Wilderness (Yes/No)	No	• Three (3) downed trees varying from 2" - 10" in diameter.
Use Level (Low/Mod/Hi)	Low	• Four (4) uprooted trees across trail.
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.3	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$2,050.00	**COMMENTS:** Tread material for rehab [illegible]k located on site. Use of Bobcat/Trail Machine will cut down number of staff days required to rehab this trail.
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Trail needs additional waterbars/checkdams, minor tread reconstruction, and debris cleaning.	**TOTAL TRAIL LENGTH:** 1.6 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Ragged Run	Need to pull ditches, clean culverts, put material back on road (15 loads).
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Low	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	10	
Cost Estimate	$4,000.00 ($2,000 for mix)	COMMENTS: Need to replace culvert pipes 350 feet. Haul mix material (40 loads).
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Maintain to pre-flood level.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Rapidan Road - Chapman Mountain	
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$12,000.00	**COMMENTS:** Need to replace culvert pipes. Haul mix material (20 loads). Grade - pull ditches.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No (initially yes)	
Potential Hazards to Hikers	No	
Recommendations	Only access to Rapidan area.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Rose River Fire Road	
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	2	
Estimated Staff Days (required for rehab)	30	
Cost Estimate	$9,500.00 ($5,000 gravel)	COMMENTS: Need to pull ditches and haul material, 20 loads.
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations	Improve to pre-flood condition.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Saddle Trail Access Road	• 1-foot deep erosion (gullies) on .2 mile steep section.
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow/Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.2	
Estimated Staff Days (required for rehab)	2	
Cost Estimate	$800.00	COMMENTS: AKA = "Old Rag Shelter access road"
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Haul/dump 18 tons of tread material and regrade.	TOTAL TRAIL LENGTH: 0.8 mile.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	South River	This fireroad has been rough grade. Washed out areas have been filled in and ditches will need to be pulled.
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	10	
Cost Estimate	$3,500.00 ($2,000 for mix)	COMMENTS: Need to access to wildlife management area.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No (temporarily lost - 2 months)	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No (after grading)	
Recommendations	Open this fireroad as it serves as an important access to the wildlife management area.	

Damage Level:1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	South River Trail	• Moderate erosion throughout trail.
Location/District	Central	• Several large blowdowns ranging from 10" - 24" in diameter.
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.1	
Estimated Staff Days (required for rehab)	15	
Cost Estimate	$2,000.00	**COMMENTS**: Numerous (imminent threat) hazardous trees throughout this trail.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	No	
Recommendations	Add checkdams and cribbing; reconstruct waterbars.	**TOTAL TRAIL LENGTH:** 1.6 miles.

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Upper Staunton River Trail	• Severe tread erosion throughout entire trail; erosion is 2'- 3' deep in some places.
Location/District	Central	• Many large blowdowns (one is 48" in diameter).
Wilderness (Yes/No)	No	• Major rock/mudslides.
Use Level (Low/Mod/Hi)	Moderate	• Trail may have to be rerouted in some areas.
Blaze (Yellow/Blue/White)	Blue/Yellow (upper 0.6 miles)	• Possible NEPA/106 compliance needed.
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	40	
Cost Estimate	$4,100.00	COMMENTS: Presently this trail is closed to hiking (area closed to fishing, BC camping). Recommendation: after upper trail is stabilized, rehabbed and compliance done, trail down to the Jones Mtn. trail intersection to provide a circuit hike. Close train below Staunton River and Jones Mtn trail intersections w/signs and a natural barricade.
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	Yes	
Recommendations	Many sections of trail need to be rerouted; sidehilling, cribbing needed, and some debris removal.	TOTAL TRAIL LENGTH: 2.4 miles.

Damage Level:1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Weakley Hollow Fire Road	Removed road material that filled ditches and plugged culverts in some areas. Will need to pull ditches, clean culverts, and grade with 15 loads of material.
Location/District	Central	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	1	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$8,000.00 ($5,000 gravel)	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	No	
Potential Hazards to Hikers	None	
Recommendations	Maintain to pre-flood level.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SOUTH DISTRICT

ROADS/TRAILS

ASSESSMENT

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Browns Gap Road	outlets/dips/ditches filled with sediment. Wet areas need regrading.
Location/District	South	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Low	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0.3	
Estimated Staff Days (required for rehab)	6	
Cost Estimate	$600.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	Unknown at this time	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS District Road Crew.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Doyles River Trail	All waterbars and lateral drains are full of sediment. Some minor rutting of tread. Large fallen trees created large hole in tread near upper falls.
Location/District	South	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0.1	
Estimated Staff Days (required for rehab)	8	
Cost Estimate	$800.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS, YCC, and PATC Trail Crews.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	**Description of Damage**
Trail Name	Hightop/Smith Roach Gap Road	Outlets/dips/ditches filled with sediment. Wet areas need regrading. Culverts need cleaning or replacement.
Location/District	South	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Low	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0.2	
Estimated Staff Days (required for rehab)	3	
Cost Estimate	$300.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	No	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS District Road Crew.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	**Description of Damage**
Trail Name	Jones Run Trail	All waterbars and lateral drains are full of sediment. Some minor rutting of tread. Repaid damaged culverts.
Location/District	South	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Low	
Length of Tread Damage (Miles)	0.2	
Estimated Staff Days (required for rehab)	8	
Cost Estimate	$800.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS, YCC, & PATC Trail Crews.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	N.F. Moormans River Road (upper 1.0 mile)	Extensive rutting on roadbed. Numerous mini-landslide areas fill ditches. Culverts need cleaning or replacement.
Location/District	South	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Moderate/Special Use Permittees	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.5	
Estimated Staff Days (required for rehab)	12	
Cost Estimate	$1,500.00	**COMMENTS**: This road should be repaired and hardened as soon as possible to accommodate increased Special Use Permittee traffic who would normally use lower NFMR Road.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	Unknown at this time	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS District Road Crew.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	N.F. Moormans River Road (lower 3.5 miles)	This section of road may be impacted beyond repair as a road. Estimate below of work to establish foot/horse trail along path of former road:
Location/District	South	**Reroute:** 6 areas: 1,380' **Reconstruct:** 22 areas: 4,745' **Regrade:** 16 areas: 3,263' **Rebuild:** 3 stream crossings: 913'
Wilderness (Yes/No)	No	Cost would be reduced by using volunteer or youth crews, such as YCC or SCA crews.
Use Level (Low/Mod/Hi)	High	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	High	
Length of Tread Damage (Miles)	3.5	
Estimated Staff Days (required for rehab)	500	
Cost Estimate	$60,000.00	**COMMENTS:** High visitor use area near Charlottesville Reservoir. Visitor use likely to increase over time. Park Management will need to decide whether to repair road or downgrade to foot/horse trail if funding is available. Trail construction could be done in phases: **1st phase** - south boundary to Big Branch Falls; **2nd phase** - Big Branch to north boundary. Watershed & Special Use Permittees considerations in this area.
Priority Level (Low/Mod/Hi) (for trail rehab)	Low	
Boundary Access Lost?	No	
Trail Sections Obliterated?	30 sections	
Potential Hazards to Hikers	Landslides, unstable road	
Recommendations	Civil engineer evaluate existing road. consider downgrading road to foot & horse trail.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Paine Run Trail	Water ran on trail for long distances rutting and washing out tread. Stream crossings need to be rebuilt for horse traffic.
Location/District	South	
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	2	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$2,000.00	**COMMENTS**: Stabilize tread with 100 checkdams and waterbars.
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Stream crossings for horses	
Recommendations	Make repairs in 1995 with NPS, YCC, and PATC Trail Crews.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Riprap Trail	600 feet of tread washed out by high water. Rebuild cribbing. All waterbars are full of sediment. Some minor rutting of tread.
Location/District	South	
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.5	
Estimated Staff Days (required for rehab)	20	
Cost Estimate	$2,000.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	Two (2) sections	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS, YCC, and PATC Trail Crews.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	S.F. Moormans River Road	Outlets/dips/ditches are filled with sediment. Wet areas need regrading. Culverts need cleaning or replacement.
Location/District	South	
Wilderness (Yes/No)	No	
Use Level (Low/Mod/Hi)	Low	
Blaze (Yellow/Blue/White)	Yellow	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.5	
Estimated Staff Days (required for rehab)	6	
Cost Estimate	$600.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	Moderate	
Boundary Access Lost?	Unknown at this time	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS District Road Crew.	

Damage Level: 1) Low Damage (Routine Maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

SHENANDOAH NATIONAL PARK
Trail/Fire Road Damage Assessment (7/95)

	Trail/Fire Rd.	Description of Damage
Trail Name	Wildcat Ridge Trail	All waterbars are full of sediment. Some minor rutting of tread.
Location/District	South	
Wilderness (Yes/No)	Yes	
Use Level (Low/Mod/Hi)	Moderate	
Blaze (Yellow/Blue/White)	Blue	
Damage Level (Low/Mod/Hi)	Moderate	
Length of Tread Damage (Miles)	0.1	
Estimated Staff Days (required for rehab)	4	
Cost Estimate	$400.00	COMMENTS:
Priority Level (Low/Mod/Hi) (for trail rehab)	High	
Boundary Access Lost?	No	
Trail Sections Obliterated?	None	
Potential Hazards to Hikers	Hazard trees (pre-flood)	
Recommendations	Make repairs in 1995 with NPS, YCC, and PATC Trail Crews.	

Damage Level: 1) Low Damage (Routine maintenance)
2) Mod Damage (Crew work, tread reconstruction)
3) Hi Damage, (Trail reroute, new construction, project clearance)

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-155 April 1997

END

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